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Факультет вычислительной математики и кибернетики

COMPUTATIONAL THINKING

КОМПЬЮТЕРНОЕ МЫШЛЕНИЕ
для студентов старших курсов и аспирантов

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Под редакцией Кругловой М.А. и Саратовской Л.Б.

Учебное пособие

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Предисловие

Овладение языковой и коммуникативной компетенциями является неотделимой составляющей профессиональной подготовки специалистов на факультете ВМК в Московском Государственном университете им. М.В. Ломоносова. В настоящее время в связи с сильно расширившимися международными контактами в области компьютерной науки успешное решение вопросов кадрового роста выпускников во многом зависит от качества их языковой подготовки.

Данное учебное пособие предназначено для студентов старших курсов, специалистов в области вычислительной техники, учащихся магистратуры и аспирантов. Оно состоит из 8 разделов, посвященных последним проблемам и достижениям в области искусственного интеллекта, нанотехнологий, экологичных вычислений и др. Аутентичные материалы взяты из специализированных источников: *Journal of Online Education, IEEE Control Systems Magazine, American Control Conference, Communications of the ACM*, *Natural Computing* journal, русских и англоязычных СМИ, и имеют целью дополнить учебники по английскому языку.

Послетекстовые задания, в основном, носят проблемный характер и ставят целью развитие логического мышления учащихся, их умения аргументировать, переводить не только с английского на русский язык, но и с русского на английский, помогают овладеть навыками реферирования и написания эссе по прочитанным материалам.

К пособию прилагается справочный материал в разделе **Appendix**, призванный помочь учащимся овладеть навыками грамотного написания эссе, докладов, и подготовке к устным презентациям.

Авторы выражают надежду, что включенные в сборник статьи помогут более эффективно организовать самостоятельную работу студентов и подготовить их к практической деятельности по своей специальности.

От редактора

Computational Thinking

Words and phrases:

Computational thinking	- компьютерное, вычислительное мышление
To draw on	- выявлять,
Tangible device	- реальное устройство
A rule of thumb	- практический метод, эвристическое правило
Brainstorming	- групповой метод решения сложных задач
Sheer bulldozing power	- исключительно за счет вычислительной мощности
Embellishment	- преувеличение
Unifying theme	- объединяющая тема
Intrinsic purposes	- присущий, свойственный

Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.
Albert Einstein

Computer scientists see the value of thinking abstractly, thinking at multiple levels of abstraction, abstracting to manage complexity, abstracting to deal with scale, etc. What do we mean by computational thinking and what are the benefits of being able to think computationally?

The statement quoted above captures the essence of computational thinking. The term Computational Thinking (CT) was coined by Jannette Wing while she was head of the Computer Science Department at Carnegie Mellon. Computational thinking involves using the capabilities of one's (human) brain and the capabilities of computer (brains) to represent and solve problems and accomplish tasks by an information-processing agent, or more generally, by combinations of humans and machines. Education for computational thinking involves learning to make effective use of these two types of brains.

Here is a more recent description of computational thinking: Computational thinking is a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science. Computational thinking is thinking in terms of abstractions, invariably multiple layers of abstraction at once. Computational thinking is about the automation of these abstractions. The automaton could be an algorithm, a Turing machine, a tangible device, a software system or the human brain.

Human brains get better through informal and formal education and through regular use. Computer brains get better through the combined research and development of many thousands of people at a rapid pace. Thus, it is essential to learn about the capabilities and limitations of the combination of human and computer brains. Each type of brain has unique capabilities and limitations. Together they are incredibly powerful.

Many adjectives describe modes of thinking: abstract, analytic, conceptual, concrete, convergent, creative, critical, deductive, divergent, strategic, synthetic, tactical, and also computational and procedural. Computational thinking is used in the design and analysis of problems and solutions, broadly interpreted. The most important and high-level thought process in computational thinking is the abstraction process. Abstraction is used in defining patterns, generalizing from instances, and parametrization. It is used to let one object stand for many, to capture essential properties common to a set of objects while hiding irrelevant distinctions among them. For example, an algorithm is an abstraction of a process that takes inputs, executes a sequence of steps, and produces outputs to satisfy a desired goal. An abstract data type defines an abstract set of values and operations for manipulating those values, hiding the actual representation of the values from the user of the abstract data type. Designing efficient algorithms inherently involves designing abstract data types. Abstraction gives us the power to scale and deal with complexity. Recursively applying abstraction gives us the ability to build larger and larger systems, with the base case, at least for computer science being bits (0's and 1's). Computational thinking draws on both mathematical thinking and engineering thinking. Unlike other engineering disciplines, because of software computing that makes possible building virtual worlds that are unconstrained by physical reality.

Computational and procedural thinking are fundamental ideas in the discipline of computer and information science. A computer is a machine that automatically, rapidly, and accurately carries out the steps in certain types of procedures. Computer programmers think in terms of solving problems and accomplishing tasks through the use of procedures. The procedures may be algorithmic or heuristic, or a combination of these two approaches. An algorithm is a step-by-step set of directions guaranteed to achieve a task, which may be to solve a particular problem in a finite number of steps.

A heuristic is like an algorithm except that the accomplishment of a specific task or solution of a specific problem is not guaranteed. Many heuristics are called "rules of thumb," simple-sounding guides that often conceal complexities. For example, one heuristic for solving a complex problem is to break the problem into smaller, more manageable problems. Solve each of the smaller problems, put the results together, and the larger problem is solved. But, there is no guarantee that one will be able to solve all of the smaller problems, and there is no guarantee that one can figure out how to break the large problem into appropriate pieces.

Brainstorming is a group process heuristic for addressing a complex problem. In brainstorming, people suggest ideas and these are collected without comment by the person facilitating the brainstorming. Later, the group analyzes the brainstormed ideas, deciding on which ones are worthy of further study. Brainstorming is often a useful process (heuristic), but there is no guarantee that it will lead to a good solution to the problem under consideration. Developing algorithms and heuristics can be very mentally challenging.

Computational thinking is the new literacy of the 21st century. It enables a person to bend computation to his or her needs. Computational thinking for everyone means being able to:

- Understand what aspects of a problem are amenable for computation
- Evaluate the match between computational tools and techniques and the problem
- Understand the limitations and the power of computational tools and techniques
- Apply or adapt a computational tool or technique to a new use
- Recognize opportunity to use computation in a new way
- Apply computational strategies such as " divide and conquer" in any domain.

Computational thinking for scientists and engineers, and other professionals means being able to:

- Apply new computational methods to their problems
- Reformulate problems to be amenable to computational strategies
- Discover new science through analysis of large data.

Computers are too important to overrate or underrate. There is no real point in sensationalizing or exaggerating activities which are striking enough without embellishment. There is no point in belittling, either. It is hardly an insult to existing computers that they fall considerably short of the human brain and are not creative. The difference simply emphasizes with new force the complexity and capabilities of the nervous system, and challenges us to study it as well as our machines

more deeply. The more we learn about computers, the better we shall understand and appreciate the nature of thought - and the better we shall use our brains. Notice that the first paragraph mentions the idea of machine learning. Machine learning has grown to be an important component of the field of Artificial Intelligence. Machine learning is defined as a "Field of study that gives computers the ability to learn without being explicitly programmed".
The history of electronic digital computers includes the development of three important ideas:

- Computers could process both numeric and non-numeric symbols, and thus could be used for many tasks other than just arithmetic computation. Computer Science (CS) or Computer and Information Science (CIS) is an academic discipline and a significant area of study, research, and development.
- Information and Communication Technology (ICT) provides powerful aids to solving problems in every discipline. It is a major change agent in human societies throughout the world. Initially, many computer scientists were interdisciplinary scholars, studying both CIS and deep applications of this new discipline in other disciplines. Eventually, CIS grew in both breadth and depth, and it became an important discipline in its own right.
- Sub-disciplines were developed such as analysis of algorithms, artificial intelligence, computability, databases, networking, and so on. Moreover, computers became more and more cost effective, and the whole field of Information and Communication Technology (ICT) blossomed.

Computational thinking as a discipline is far more than a collection of isolated pieces. Learning a discipline and learning to use or apply a discipline at a high level are far more than learning isolated facts, tools, and ideas. As a discipline grows and matures, its leaders give considerable thought to identifying unifying themes. Computational thinking is a unifying theme in the computer field and in the uses of computers in every discipline. Using a computer system involves telling the system what you want it to do. So, to get started you first need to think about what you are trying to accomplish and what parts of the task the computer can help with. You need to understand the capabilities and limitations of the computer system that will be relevant to addressing the problem that you have in mind.

Computational thinking refers to people and computers working together to solve problems and accomplish tasks. Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence. What can humans do better than computers, and what can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answer to such questions.

Computer science interacts with almost every other discipline. Computational biology, computational chemistry, computational design, computational finance, computational linguistics, computational logic, computational mechanics, computational neuroscience, computational physics, and computational and statistical learning are just a few examples of such interdisciplinary fields of study. In education, undergraduate computer science curriculum and outreach programs teach students how to think like a computer scientist. The message is that computer science is not just about programming, but about thinking. Our long-term vision is to make computational thinking commonplace for everyone, not just computer scientists.

A computer program is a detailed set of instructions that can be interpreted and carried out by a computer. A computer is a machine that can quickly and accurately follow (carry out, execute) the detailed step-by-step set of instructions in a computer program. Computer programmers design, write, and test computer programs — so they are deeply involved in doing computational thinking. However, all computer users are involved in computational thinking at some level, as they interact with a computer and tell it what they want done. This is true whether you are playing a computer game, retrieving information from the Web, or using a word processor.

The underlying idea in computational thinking is developing models and simulations of problems that one is trying to study and solve. We are all familiar with the idea of developing mental models — we form mental representations of a problem and often we "play the mental images" in our heads, doing a mental simulation. We are also aware of the value of developing a mathematical representation of a problem. The value of math modeling lies in the huge accumulation of knowledge about solving a wide range of different math problems. If a problem can be represented mathematically (that is, if a math model can be developed for a problem) then this might well prove to be a powerful aid to solving the problem.

Computer models have some of the characteristics of mental modeling as well as some of the characteristics of math modeling and the types of modeling done in other disciplines. If a problem lends itself to computer modeling, then the computer may well be able to carry out the steps (procedures, symbol manipulations) needed to solve the problem.

Thus, computational thinking, integrating human thinking with the capabilities of computers, provides a powerful new way to solve problems. The computer aspects of computational thinking require one to know the capabilities and limitations of computers and how one communicates with (interacts with) a computer system. From an educational point of view, a key aspect of studying any discipline now includes:

- Learning some of the capabilities and limitations of computers as an aid to representing and solving the problems of the discipline.
- Learning how to actually make use of these computer capabilities.
- Learning how to think about problems in the discipline both from a traditional point of view and from a point of view of the possible uses of computers to help solve the problems.

Computational thinking has already influenced the research agenda of all science and engineering disciplines. Starting decades ago with the use of computational modeling and simulation through today's data mining and machine learning to analyze massive amounts of data, computation is recognized as the third pillar of science along with the theory of experimentation. The volume and rate at which scientists and engineers are now collecting and producing data – through instruments, experiments, and simulations – are demanding advances in data analytics, data storage and retrieval, and data visualization.

Computational thinking has also begun to influence disciplines and professions beyond science and engineering. For example, the areas of active study include algorithmic medicine, computational archeology, computational economics, computational finance, computational law, computational social science, and digital humanities. Data analytics is used in training Army recruits, spam and credit card detection, recommendation and reputation services.

Computers have had a much larger impact in some disciplines than in others. The search for aids to the symbol manipulation (the computations based on algorithmic heuristic procedures) has been going on for many thousands of years. The abacus was a very important early success — an aid many use today. Math tables, logarithms, the slide rule, and mechanical calculators were all quite important aids to arithmetic computation. Now, we have electronic digital calculators and computers. We have quite inexpensive solar battery-powered scientific calculators that are superb improvements over earlier aids to numerical computations. We have computers that can do the types of symbolic manipulation needed in many different algebraic, calculus, and statistics computations.

Computer systems can graph functions and statistical data, but they can also do graphical displays of the types of models used in many other disciplines. For example, an architect can develop a computer model of a planned building. The computer can do computations to test the structural integrity, fire and storm resistance, heating and cooling requirements, and so on. A computer system can provide users with a three-dimensional structured walk-through of a planned building before physical work begins. These are all humongous computational tasks, based on accumulated knowledge in math, physics, and other disciplines.

Information as in Information Age has different meanings to different people. The following quote is from Marc Prensky (February/March 2009): “Digital technology, I believe, can be used to make us not just smarter but truly wiser. Because of technology, wisdom seekers in the future will benefit from unprecedented, instant access to ongoing worldwide discussions, all of recorded history, everything ever written, massive libraries of case studies and collected data, and highly realistic simulated experiences equivalent to years or even centuries of actual experience...But the digitally unenhanced person, however wise, will not be able to access the tools of wisdom that will be available to even the least wise digitally enhanced human.”

Humans and computer systems, working and "thinking" together, are now routine approaches to problem solving. Computer hardware capabilities are continuing a rapid pace of improvement (See Moore’s Law). A steadily increasing range of problems can be solved through computer modeling and making effective use of the capabilities of computers. A steadily increasing amount of the accumulated knowledge of humankind is being put into a digital form so a computer system can do part of the work of retrieving and making use of the information.

Cyber-Enabled Discovery and Innovation (CDI) is NSF's bold five-year initiative to create revolutionary science and engineering research outcomes made possible by innovations and advances in computational thinking. Computational thinking is defined comprehensively to encompass computational concepts, methods, models, algorithms, and tools. Applied in challenging science and engineering research and education contexts, computational thinking promises a profound impact on the Nation's ability to generate and apply new knowledge. Collectively, CDI research outcomes are expected to produce paradigm shifts in our understanding of a wide range of science and engineering phenomena.

Computing has permeated and transformed almost all aspects of modern life. As computing becomes more important in all sectors of society, so does the preparation of a globally competitive workforce able to apply core computing concepts, methods, technologies, and tools - referred to here as Computational Thinking (CT) - to a broad range of societal challenges and opportunities. CT capitalizes on concepts, methods, technologies, and tools fundamental to the fields of computing, i.e. computer and information science and engineering. For example, computing concepts and methods equip us to reason at multiple levels of abstraction simultaneously, to think algorithmically and apply foundational mathematical concepts to solve complex problems, and to understand the dimensions and consequences of scale. However, it is only when computing concepts and methods are combined with the power of automation afforded by contemporary computing technologies and tools that the full potential of CT is unleashed. Drawing deeply on computational concepts, methods, technologies and tools, CT serves as a powerful strategy to more effectively design, understand and solve problems associated with complex systems in many aspects of modern life.

Notes:

Carnegie Mellon University – a private research university in Pittsburgh, Pennsylvania (USA) recognized for world-class arts and technology programs

A heuristic – an experience-based technique for problem solving that gives a solution which is not guaranteed to be optimal

Moore's Law – an observation that the number of transistors on integrated circuits doubles approximately every two years

NSF – National Science Foundation, a US government agency that supports fundamental research and education in all non-medical fields of science and engineering

A rule of thumb – a principle that is not intended to be strictly accurate

An automaton – a self-operating machine

A divide and conquer algorithm – works by breaking a problem into sub-problems

Exercises

1. Give Russian equivalents to the following words and phrases and explain them in your own words:

To augment the scientific method; in a nutshell; multidisciplinary thinking; problem decomposition; pattern recognition; pattern generalization; data visualization; to filter out information; to develop step-by-step strategy; algorithm is written abstractly; utilizing variables; draw on math as a foundation; to be constrained by the underlying machine; integral to human endeavors.

2. Translate the sentences into Russian paying attention to the prefixes and suffixes:

1. Computational thinking is thinking in terms of abstractions, **invariably** multiple layers of abstraction at once.

2. Abstraction is used in defining patterns, generalizing from instances, and **parametrization**.
3. Software computing makes possible building virtual worlds that are **unconstrained** by physical reality.
4. One heuristic for solving a complex problem is to break the problem into smaller, more **manageable** problems.
5. Doing arithmetic, solving mathematical equations by sheer bulldozing power, is not the most significant of the machines' **accomplishments**.
6. Computers are thinking aids of enormous **potentialities**.
7. Computers are too important to **overrate** or **underrate**.
8. There is no real point in **sensationalizing** or exaggerating activities which are striking enough without **embellishment**.
9. Initially, many computer scientists were **interdisciplinary** scholars, studying both CIS and deep applications of this new discipline in other disciplines.
10. In education, undergraduate computer science curriculum and **outreach** programs teach students how to think like a computer scientist.
11. A computer system can provide users with a three-dimensional structured **walk-through** of a planned building before physical work begins.
12. In an **unimaginably** complex future, the digitally **unenhanced** person, however wise, will not be able to access the tools of wisdom that will be available to even the least wise digitally enhanced human."

3. Give English equivalents to the following words and phrases:

Различные уровни абстракции; уловить суть; возможности компьютера; эффективно использовать; фундаментальные понятия; термин был придуман ...; с большой скоростью; несущественные отличия; соответствовать желаемой цели; конечное количество шагов; мозговой штурм; дополнительные возможности; грамотность; подчиняться чьим-то требованиям;

проблемы, поддающиеся вычислительной стратегии; преуменьшать; нет смысла...; выполнять инструкции

4. Answer the following questions:

1. What methods does computational thinking employ to reveal realities hidden within data?
2. How do simulation, visualization, data analysis and abstraction serve the scientific method search for mechanisms, relationships and the truths and realities hidden within data?
3. Why is it important for a practitioner in computer science to have confidence to look inside the computing 'black box' and to have the courage to be non-expert on some parts of the problem?
4. Why may a scientifically correct answer contain uncertainties? How simplicity may be present in complexity, once we expand the way we look at objects?
5. Why is it more important for a computational scientist to have an accurate and reliable answer to a particular problem than the fastest one, and why is this surprisingly hard?
6. How can one understand multiple diciplines needed to solve a problem more easily?
7. What are the integral parts of the computational thinking process?

5. Decide whether the statements are true or false :

1. Computational thinking is a process involved in mental activity of a person to facilitate his or her personal decision making.
2. Computational thinking is a way of solving problems, designing systems, and understanding human behaviour that draws the concepts fundamental to computer science.
3. To flourish in today's world, computational thinking has to be a fundamental part of the way people think and understand the world.
4. Users of the Internet, without skills of computational thinking, will demistify privacy technologies to surf the Web

safely.
5. Computational thinking means creating and making use of different levels of abstraction, to understand and solve problems more effectively.
6. Computational thinking means thinking algorithmically and without the ability to apply mathematical concepts such as induction to develop more efficient, fair, and secure solutions.
7. Computational thinking means understanding the consequences of the scale, not only for reasons of efficiency but also for economic and social reasons.

6. Translate from Russian into English:
1. С появлением кибернетики, компьютеров и компьютерных систем, которые стали называть интеллектуальными системами, с развитием направления «Искусственный Интеллект» мышление, интеллект стали предметом интереса математических и инженерно-технических дисциплин.
2. Компьютерное моделирование дало мощный толчок исследованиям механизмов познавательной деятельности в рамках такого направления как психология.
3. Компьютерное моделирование мышления, использование методов математических и технических наук в его исследовании породило надежды на создание строгих теорий мышления.
4. В последние два десятилетия в компьютерной науке заметное внимание уделяется такому предмету как знание, которое стало использоваться в названиях направлений и компьютерных систем, основанных на знаниях.
5. Теория искусственного интеллекта стала иногда характеризоваться как наука о знаниях, о том, как их добывать, представлять в искусственных системах, обрабатывать внутри системы и использовать для решения задач.

7. Summarize the text and express your own opinion. Here are some possible statements to support:

1. Computational thinking is the thought process involved in formulating problems and their solutions to be carried out by an information-processing agent.
2. Computational thinking incorporates logical thinking and system thinking.
3. Computational thinking enables you to bend computations to your needs.
4. Computational thinking gives you the ability to ask questions that were not dared to ask because of scale.
5. Computational thinking helps to recognize an opportunity to use computation in a new way.

8. Develop the following ideas in writing an essay (120 -150 words).

1. It is nearly impossible to do research in any scientific or engineering discipline without an ability to think computationally.
2. The impact of computing extends far beyond science affecting all aspects of our lives, and to flourish in today's world, everyone needs to master computational thinking.

Model Predictive Control Using Neural Networks

Words and phrases:

Model predictive control - (MPC)	-	система управления с использованием модели прогнозирования (экстраполяции)
Constrained problems	-	задачи с ограничениями
Multivariable systems	-	многосвязная система
Intrinsic	-	свойственный, присущий
Debilitate	-	ослаблять
Predictor	-	предсказывающее устройство, прогнозирующий параметр
Controller	-	управляющее устройство, конроллер
Dynamic matrix	-	динамическая матрица
Special causes	-	особые причины
Viscosity	-	вязкость
Derivation of a model	-	деривация модели
Open-loop experiments	-	эксперименты с разомкнутым циклом
Excitation	-	возмущение
Topology	-	топология (сети)
Feedforward network	-	сеть с механизмом прогнозирования событий
Arbitrary	-	произвольный
Convergence	-	сходимость
Sigmoid function	-	сигмоидная функция
Backpropagation	-	обратная связь (при обучении нейронной сети)
Mapping capability of the network	-	свойство преобразования данных
High gain area	-	область высокого прироста
Prediction horizon	-	горизонт прогнозирования
Disturbance rejection	-	подавление возмущения
Gradient-based method	-	градиентный метод
Training runs	-	прогоны обучения

Prediction horizon - горизонт прогнозирования
Disturbance rejection - подавление возмущения

Model predictive control (MPC) is widely adopted in the process industry as an effective means to deal with large multivariable constrained control problems. The main idea of MPC is to choose the control action by repeatedly solving on line an optimal control problem. This aims at minimizing a performance criterion over a future horizon, possibly subject to constraints on the manipulated inputs and outputs, where the future behavior is computed according to a model of the plant. MPC has been used in industry for more than 30 years, and has become an industry standard (mainly in the petrochemical industry) due to its intrinsic capability for dealing with constraints and with multivariable systems. Most commercially available MPC technologies are based on a linear model of the process. For processes that are highly nonlinear, the performance of an MPC based on a linear model can be poor. This has motivated the development of Nonlinear Model Predictive Control (NMPC), where a more accurate (nonlinear) model of the plant is used for prediction and optimization. **Predictive Constrained Control**

PID type controllers do not perform well when applied to systems with significant time-delay. Perhaps the best known technique for controlling systems with large time-delays is the Smith Predictor. It overcomes the debilitating problems of delayed feedback by using predicted future states of the output for control. If there is no time-delay, these algorithms usually collapse to the PID form. Predictive controllers can also be embedded within an adaptive framework.

Multivariable Control

Most processes require the monitoring of more than one variable. Controller-loop interaction exists such that the action of one controller affects other loops in a multi-loop system. Depending upon the interrelationship of the process variables, tuning each loop for maximum performance may result in system instability when operating in a closed-loop mode. These types of controllers are not designed to handle the effects of loop interactions. A multivariable controller, whether Multiple Input Single Output (MISO) or Multiple Input Multiple Output (MIMO) is used for systems that have these types of interactions. A model-based controller can be modified to accommodate multivariable systems. Loop interactions are considered as feed-forward disturbances and are included in the model description. Following SISO designs, multivariable controllers that can provide time-delay compensation and handle process constraints can also be developed with relative ease.

Model-Based Predictive Control

Model-Based Predictive Control technology utilizes a mathematical model representation of the process. The algorithm evaluates multiple process inputs, predicts the direction of the desired control variable, and manipulates the output to minimize the difference between target and actual variables. Strategies can be implemented in which multiple control variables can be manipulated and the dynamics of the models are changed in real time.

Dynamic Matrix Control

Dynamic Matrix ControAl (DMC) is also a popular model-based control algorithm. A process model is stored in a matrix of step or impulse response coefficients. This model is used in parallel with the on-line process in order to predict future output values based on the past inputs and current measurements.

Statistical Process Control

Statistical Process Control (SPC) provides the ability to determine if a process is stable over time, or, conversely, if it is likely that the process has been influenced by "special causes" which disrupt the process. Statistical Control Charts are used to provide an operational definition of a "special cause" for a given process, using process data. SPC has been traditionally achieved by successive plotting and comparing a statistical measure of the variable with some user defined control limits. "On-line SPC" is the integration of automatic feedback control and SPC techniques. Statistical models are used not only to define control limits, but also to develop control laws that suggest the degree of manipulation to maintain the process under statistical control. This technique is designed specifically for continuous systems. Manipulations are made only when necessary, as indicated by detecting violation of control limits. As a result, savings in the use of raw materials and utilities can be achieved using on-line SPC.

Neural Network-based Control

The model predictive control method (MPC) is primarily developed for process control using artificial neural networks. Conventional MPC uses linear model of the system for prediction which leads to inaccuracy for highly non-linear systems, such as robots. In recent years, the requirements for the quality autonomic control in the process industries increased significantly due to the increased complexity of the plants and sharper specifications of product quality. At the same time, the available computing power increased to a very high level. As a result, computer models that are computationally expensive became applicable even to rather complex problems. Model-based complex techniques were developed to obtain tighter control.

Model predictive control was introduced successfully in several industrial plants. An important advantage of these control schemes is the ability to handle constraints of actuated variables and internal variables. In most applications of model predictive techniques, linear model is used to predict process behavior over the horizon of interest. As most real processes show a nonlinear behavior, some work was done to extend predictive control techniques to incorporate nonlinear models. The most expensive part of the realization of a nonlinear predictive control scheme is the derivation of the mathematical model. In many cases it is even impossible to obtain a suitable physically founded process model due to the complexity of the underlying process or the lack of knowledge of critical parameters (as temperatureand pressure-dependent mass transfer coefficients or viscosities) of models. A promising way to overcome these problems is to use neural networks as nonlinear black-box models of the dynamic behavior of the process.

Such neural network can be derived from measured input/output data of the plant. Usually, special open-loop experiments are performed to provide the data to train neural nets. In many practical cases, however, conventional controllers are in use at the plant which stabilize the plant and provide some basic, sometimes sluggish control. Measurements of input/output variables of the plant operated with the linear controller may provide very good training data for the neural network. This approach is more practical (the plant is always under automatic control) and more effective than using experiments without control (open-loop identification).

The Neural Network and Training Algorithm Topology

For the prediction of the behavior of the neutralization reactor, we chose a feedforward network with sigmoid activation functions. This class of neural networks is well known and relatively well understood. Feedforward nets are easily implemented under real-time conditions. A disadvantage is that the training effort is usually high, which makes it difficult and time-consuming to explore various structures and to optimize the network structure. We overcame this problem, to a certain degree, by improving the training algorithms and by using several PCs in parallel in the training process. Feedforward nets with at least one hidden layer have the capability to approximate any desired nonlinear mapping to an arbitrary degree of accuracy. The neural net considered here consists of four layers: one input layer, two hidden layers, and one output layer. Even though networks with only one hidden layer already have the desired approximation power, our experience is that two hidden layers give better convergence in the training process.

As inputs the actual and the last four old pH-values and the corresponding five values of the impulse frequency (which determines the sodium hydroxide flow) are fed into the network. The hidden layers consist of 10 neurons each, while the output layer consists of one neuron, the predicted next value of pH. The network thus performs a one-step ahead prediction. In the predictive control scheme, however, it is used for a multi-step prediction by applying it recursively, i.e. past values of pH are replaced by predicted values. To use the neural net in this fashion requires a very good one-step-ahead prediction accuracy. The network topology was chosen based on experiments with different structures. It is obvious that the net is redundant in the sense that from system-theoretic considerations, two past inputs should be sufficient because the order of the physical system is 2, at least in a first approximation, if the sensor dynamics are included. The results, however, were much better with more delayed inputs corresponding to a distribution of the information to more nodes than necessary. The same applies to the number of nodes in the hidden layers. The structure chosen is not minimal (and there is not much point in squeezing it to the limit), but the one that gave the best compromise in terms of robust prediction vs. training effort. The prediction error is not very sensitive to the number of neurons in the hidden layer.

Training Algorithm

In order to make the neural network perform the desired time-consuming to explore various structures and to optimize the mapping from the input layer to the output layer, one usually searches for the optimal connection weights w,, between the neurons to approximate the desired mapping by so-called training algorithms. The most popular training algorithm for feedforward networks with sigmoid activation functions is the generalized delta-rule or backpropagation where E is the sum of the squares of the differences between network outputs and the desired outputs (targets) L for the set of R training patterns. As the backpropagation algorithm is a steepest descent method, it has the disadvantage of converging very slowly and being vulnerable to getting caught in local minima of E. To overcome these disadvantages, a so-called momentum term can be included to slide over small minima in the error surface: For further acceleration, the step size K can be chosen individually for each weight in the net and can also be adapted according to the learning progress. All these improvements result in a significant speed-up of the learning process, but there is still a tendency to be caught in local minima.

Also, the convergence properties of the algorithm are strongly dependent on the initial settings of the weights The backpropagation-based learning algorithm described above varies only the weights of the neural network to achieve the desired mapping. To overcome the dependence of the learning process on the initial settings and for a further improvement of the mapping accuracy, we use a combination of backpropagation and a genetic algorithm. The key idea is to vary the properties of each neuron in the net in addition to the adaptation of the weights. The processing properties of a neuron are determined by its activation function. We use a special type of sigmoid activation function, the so-called Fermi function:

The genetic algorithm optimizes the slopes (3 of the Fermi functions). As the output of the network is essentially a sum over all weighted activation functions, we obtain a better accuracy by allowing to change the functions during training. The vector of slopes ***0,*** in which the *i*th element denotes the slope of the Fermi function of neuron *i*, is treated as the string of genetic information. This string determines the mapping capability of the network with respect to the overall modeling error. For each slope vector *0* an appropriate set of weights is determined by applying the improved backpropagation method Super SAB to the net. The training process thus is an iteration of the genetic algorithm which tunes the slopes and backpropagation to optimize the weights for each configuration of the slopes.

Fermi Function.

In the genetic algorithm, a population of neural nets, initialized with randomly distributed weights and slope values for all neurons, is considered. The genetic algorithm consists of three parts:

1. Determine the "fitness" of each member of the population. The member with the smallest value of **E** is considered the fittest.
2. Generate a new population member by genetic operators such as mutation and recombination from old members. Train this new member a certain time with the Super SAB method and determine the fitness of the new member.
3. If the new member is better than the worst old member, replace the worst old one with the new one. Steps I to 3 are repeated until an acceptable performance by the best member is achieved. By this combination of the genetic algorithm and a modified gradient-based method, the average training time to obtain a sufficiently small error is reduced considerably because ineffective training runs are avoided.

Training Data Generation

The aim of our work is to obtain a nonlinear black-box model of a real process by training a neural net from measured data only. Other researchers in the field who treated system identification with neural networks for a neutralization process generated the training data from applying random inputs to the process. This leads to a very sparse representation of the high gain area at the point of equivalence in the training data set. In contrast to this approach, we consider a training set which is generated by the system under closed-loop control with a reasonable PI-controller. Instead of generating random input sequences to the process, we changed the set point for the linear controller randomly during plant operation under control. This leads to a sequence of setpoint steps which were tracked by the conventionally controlled system. The resulting training set consists of the two measured time series of the pump frequency and pH-value for 3.5 hours for this conventionally tracked setpoint sequence. The advantages of using data from the controlled plant go beyond the specific aspect of neutralization plants that without control the plant can hardly be operated within the most interesting.

Experimental Results

For the experiments, the neural network was trained with dataset described above. The sampling time was chosen to be equal to the sampling time used for the PI-controller, which was T = 5 s. Thus there were 2800 data points in the training set. The training algorithm described above was implemented on IBM-compatible PCs running in parallel. The required training time was 4 hours. After the completion of the training, the prediction of the network was tested with data which was not included in the training set.

The extended DMC algorithm was realized using a commercial PC-based process monitoring. The prediction horizon was chosen as NP=5, whereas the control horizon was chosen as NU=l. In contrast to the long training time, the time required to compute the network output online for the prediction and compute the controller output iteratively is short enough to be performed.

Conclusions

We have presented an approach to model predictive control of a highly nonlinear plant without a priori information about the plant dynamics other than that the plant can be controlled (with unsatisfactory performance) by a conventional controller. The process dynamics were identified from measured input/output time series only. All we needed was data from 3.5 hours of normal plant operation under linear control with varying setpoints. No special input sequences as random input signals or steps were used. We modified a nonlinear extension to the standard DMC control scheme for operation with the trained neural network. The controller was implemented using a small commercial PC based process control system and shows a significantly improved performance compared to the linear controller for setpoint tracking as well as for disturbance rejection. As we mentioned above, in contrast to the time needed for prediction, the training time for the neural network used here was quite long. Thus our research activities concentrate on networks with shorter training time for online training of time-varying process dynamics. As the DMC approach is inherently a multivariable control strategy, we are also extending the proposed control algorithm to the MIMO case.

Notes:

Model Predictive Control – an advanced method of process control intended to represent the behavior of complex dynamical systems

A **PID (a Proportional-Integral-Derivative) Controller** – a control loop feedback mechanism which calculates error value and tries to minimize it

The Smith Predictor (invented by O.J.M.Smith in 1957) – a type of predictive controller for systems with pure time delay

Artificial neural network – a computational model inspired by the brain that is capable of machine learning and pattern recognition

A sigmoid function – a mathematical function having an "S" shape (a sigmoid curve)

Exercises

1. Give Russian equivalents to the following words and phrases and explain them in your own words:

To require more than one variable; to evaluate multiple process inputs; to predict the direction of the desired control variable; to minimize the difference between target and actual variables; the requirements increased significantly; due to; a nonlinear behavior; to extend predictive techniques; to incorporate nonlinear models; a feedforward network with sigmoid activation functions.

2. Translate the sentences into Russian paying attention to the terms and abbreviations:

1. The main idea of **MPC** is to choose the control action by repeatedly solving online optimal control problems.
2. For processes that are highly nonlinear, the performance of an **MPC** based on a linear model can be poor, which has motivated the development of **Nonlinear Model Predictive Control (NMPC)**, where a more accurate (non-linear) model of the plant is used for prediction and optimization.
3. The proposed **MPC** control action is conceptually different from the traditional robot control methods in that the control action is determined by optimizing a performance index over the time horizon.
4. The training data to set up **the neural network model** core from measuring the robot joint variables and torques during the running of a real robot.
5. The research activities concentrate on networks with shorter training time for online training of **time-varying process design.**
6. In contrast to the time needed for prediction, **the training** needed for prediction, **the training time** for the neural network used here was quite long.
7. The extended **DMC algorithm** was realized using commercial PC-based process monitoring and control system.
8. In contrast to the long training time, the time required to compute the network output online for the prediction and compute **the controller output** iteratively is short enough to be performed within one sampling period in addition to the standard tasks of the monitoring and control system on a PC.

3. Give English equivalents to the following words and phrases:

Метод обратного распространения; распознавание текста; алгоритм обучения нейросети; обучение на основе опыта; в процессе обучения величина ошибки уменьшается; различные параметры и настройки; модель определяет парадигму обучения; обучение за небольшое число шагов; оценочная функция; нейронные сети используются для задач оптимизации; прогнозирование хаотических временных рядов; многослойная структура нейросети.

4. Answer the following questions:

1. What is the main idea of model predictive control?
2. Why is the Smith Predictor so appropriate to control systems with time-delay?
3. What is the essence of Model-Based Predictive Control technology?
4. How do statistical models contribute to the control processes?
5. What are the ways to extend predictive control techniques?
6. What is the problem of feedforward net implementation and how to overcome it?
7. How is the training algorithm for feedforward net implemented?
8. What are the parts of a genetic algorithm?

5. Translate from Russian into English:

Для того, чтобы нейронная сеть могла решать задачи, ее необходимо обучить. Для искусственных нейронных сетей под обучением понимается процесс настройки архитектуры сети (структуры связи между нейронами) и весов семантических связей (влияющих не сигналы коэффициентов) для эффективного решения поставленной задачи. Обычно обучение нейронной сети осуществляется на некоторой выборке. По мере процесса обучения, который происходит по некоторому алгоритму, сеть должна все лучше (правильнее) реагировать на входные сигналы.

Оказывается, что после многократного предъявления примеров веса нейронной сети стабилизируются, причем нейронная сеть дает правильные ответы на все (или почти все) примеры из базы данных. В таком случае говорят, что нейронная сеть обучена. В программных реализациях можно видеть, что в процессе обучения величина ошибки постепенно уменьшается. Когда величина ошибки достигает нуля или приемлемого малого уровня, тренировку останавливают, а полученную нейронную сеть считают натренированной и готовой к применению на новых данных. Степень достаточности обучения нейронной сети во многом определяется исходя из условий конкретной задачи и желаемого результата.

6. Summarize the text and express your own opinion. Here are some possible statements to support:

1. In general, model predictive control is a strategy which is based on the explicit use of some kind of process model to predict the controlled variables over a certain time horizon, the prediction horizon.
2. The prediction error between the measured process output and the predicted output is used for disturbance estimation.
3. For the prediction of the behavior of, for instance, the neutralization reactor, a feedforward network with sigmoid activation function is chosen.
4. The neural network consists of four layers.
5. The network topology was chosen based on experiments with different structures.
6. The prediction error is not very sensitive to the number of neurons in the hidden layer.

Biologically Inspired Computing

Words and phrases:

Relentless – безжалостный, неослабевающий
To inspire - вдохновлять
To conceive - задумывать, замышлять
To emulate - имимтировать, моделировать
Momentum - толчок, движущая сила
Permutation - преобразование, перестановка
A cellular automaton - матричный, клеточный автомат
Swarm intelligence - роевый интеллект
Amorphous computing - хаотичные вычисления
To straddle - охватывать
Unsupervised learning - неконтролируемое обучение
Foraging - добывание пищи
To exhibit - обнаруживать, проявлять
Self-replication - самовоспроизведение
Nested hierarchy - иерархия с вложениями
To delimit - разграничивать, ограничивать
Wherein - при котором
A strand - цепочка, нить, составляющая
Cut-and-paste - вырезание и вставка
Tweezers - пинцет
Entanglement - сцепленность, спутанность
Logic gates - логические элементы
To sustain - подкреплять, поддерживать
A toolkit - набор инструментальных средств
A motif - повторяющийся узор
To yield - предоставлять
A ciliate - инфузория

Despite the relentless, breathtaking advances in computing and related technologies, we continue to be humbled by the variety, adaptability, and sophistication of the natural world around us. From the beginning, a divide has grown between computational scientists on whether to continue creating faster, more efficient algorithms and hardware that exhibit centralized control or to place less emphasis on speed and efficiency than on robustness, adaptability, and emergent organization from the interaction of many loosely coupled processes. These latter approaches have come to be known as *biologically inspired computing*, which is a field that links various disciplines such as artificial intelligence, evolutionary computation, biorobotics, artificial life, and agent-based systems.

Natural computing investigates models and computational techniques inspired by nature and, dually, attempts to understand the world around us in terms of information processing. It is a highly interdisciplinary field that connects the natural sciences with computing science, both at the level of information technology and at the level of fundamental research. As a matter of fact, natural computing areas and topics include pure theoretical research, algorithms and software applications, as well as biology, chemistry and physics experimental laboratory research. A closer look at nature from the point of view of information processing can and will change what we mean by computation.

Nature as Inspiration

Among the oldest examples of nature-inspired models of computation are the cellular automata conceived by Ulam and von Neumann in the 1940s. Cellular automata have been applied to the study of phenomena as diverse as communication, computation, construction, growth, reproduction, competition, and evolution. Cellular automata have been extensively studied as an alternative explanation to the phenomenon of emergence of complexity in the natural world, and used, among others, for modeling in physics, and biology.

In parallel to early comparisons between computing machines and the human nervous system, McCulloch and Pitts proposed the first model of artificial neurons. This research eventually gave rise to the field of neural computation, brain theory or computational neuroscience, and artificial neural networks or simply neural networks.

While Turing and von Neumann dreamt of understanding the brain, and possibly designing an intelligent computer that works like the brain, evolutionary computation emerged as another computation paradigm that drew its inspiration from Darwinian evolution. Rather than emulating features of a single biological organism, evolutionary computation draws its inspiration from the dynamics of an entire species of organisms. An artificial evolutionary system is a computational system based on the notion of simulated evolution.

Evolutionary systems gained momentum in the 1960s, and evolved along three main branches: e*volution strategies* today are used for real-valued as well as discrete and mixed types of parameters; e*volutionary programming* is used today for real-valued parameter optimization problems; g*enetic algorithms* are today modified heavily for applications to real-valued parameter optimization problems as well as many types of combinatorial tasks such as, for example, permutation-based problems.

Cellular automata, neural computation, and evolutionary computation are the most established "classical" areas of natural computing. Several other bio-inspired paradigms emerged more recently, among them swarm intelligence, artificial immune systems, artificial life, membrane computing, and amorphous computing.

A computational paradigm straddling at times evolutionary computation and neural computation is *swarm intelligence.* A swarm is a group of mobile biological organisms (such as bacteria, ants, termites, bees, spiders, fish, birds) wherein each individual communicates with others either directly or indirectly by acting on its local environment. These interactions contribute to distributive collective problem solving. Swarm intelligence, sometimes referred to as collective intelligence, is defined as the problem-solving behavior that emerges from the interaction of such a collection of individual agents.

Particle swarm optimization was introduced as a new approach to optimization that had developed from simple models of social interactions, as well as of flocking behavior in birds and other organisms. A particle swarm optimization algorithm starts with a swarm of “particles”, each representing a potential solution to a problem, similar to the population of individuals in evolutionary computation. Particle Swarm Optimization algorithms have been used to solve various optimization problems, and have been applied to unsupervised learning, game learning, scheduling and planning applications, and design applications.

Ant algorithms were introduced to model the foraging behavior of ant colonies. In finding the best path between their nest and a source of food, ants rely on indirect communication by laying a pheromone trail on the way back to the nest if they found food, and following the concentration of pheromones in the environment if they are looking for food. This foraging behavior has inspired a large number of ant algorithms used to solve mainly combinatorial optimization problems defined over discrete search spaces.

Bio-inspired algorithms can exhibit strength through flexibility, or strength in numbers: they often work well even when the desired task is poorely defined, adapt to unforeseen changes in the task environment, or achieve global behavior through interaction among many, simply programmed agents.

Artificial immune systems are computational systems devised starting in the late 1980s and early 1990s as computationally interesting abstractions of the natural immune system of biological organisms. Viewed as an information processing system, the immune system performs many complex computations in a highly parallel and distributed fashion. It uses learning, memory, associative retrieval, and other mechanisms to solve recognition and classification problems such as distinction between self and nonself cells, and neutralization of nonself pathogenic agents. Indeed, the natural immune system has sometimes been called the “second brain”, because of its powerful information processing capabilities.

The applications are varied and include computer virus detection, anomaly detection in a time series of data, fault diagnosis, pattern recognition, machine learning, bioinformatics, optimization, robotics, and control. Recent research in immunology develops what is known as the "danger theory", wherein it is believed that the immune system differentiates between dangerous and non-dangerous entities. These ideas have started to be exploited in artificial immune systems in the context of computer security.

Artificial life (ALife) attempts to understand the very essence of what it means to be alive by building *ab initio*, within *in silico* computers and other "artificial" media, artificial systems that exhibit properties normally associated only with living organisms. Building on the ideas of evolutionary computation, the pioneers of artificial life experimented with evolving populations of "artificial creatures" in simulated environments. These ideas were taken one step further, by combining the computational and experimental approaches, and using rapid manufacturing technology to fabricate physical robots that were materializations of their virtually evolved computational counterparts. Many of them exhibited symmetry, some moved sideways in a crab-like fashion, and some others crawled on two evolved limbs. This marked the emergence of mechanical artificial life. At the same time, the field of Artificial Life continues to explore directions such as artificial chemistry, as well as traditionally-biological phenomena in artificial systems, ranging from co-evolutionary adaptation and development to growth, self-replication, and self-repair.

Membrane computing investigates computing models abstracted from the structure and the functioning of living cells. A generic membrane system is essentially a nested hierarchical structure of cell-like compartments or regions, delimited by "membranes". Each membrane enveloped region contains objects and transformation rules which modify these objects, as well as specify whether they will be transferred outside or stay inside the region. The transfer thus provides

for communication between regions.
The computational behavior of a membrane system starts with an initial input configuration and proceeds in a maximally parallel manner by the non-deterministic choice of application of the transformation rules, as well as of the objects to which they are to be applied. The output of the computation is then collected from an *a priori* determined output membrane. Typical applications of membrane systems include biology, computer science (computer graphics, public-key cryptography, approximation and sorting algorithms, and solving computationally hard problems), and linguistics.
Amorphous computing is a paradigm that draws inspiration from the development of form (morphogenesis) in biological organisms, wherein interactions of cells guided by a genetic program give rise to well-defined shapes and functional structures. Analogously, an amorphous computing medium comprises a multitude of irregularly placed, asynchronous, locally interacting computing elements. These identically programmed "computational particles" communicate only with particles situated within a small given radius, and may give rise to certain shapes and patterns such as, for example, any pre-specified planar graph. The goal of amorphous computing is to engineer specified coherent computational behaviors from the interaction of large quantities of such unreliable computational particles interconnected in unknown, irregular, and time-varying ways. At the same time, the emphasis is on devising new programming abstractions that would work well for amorphous computing environments. Amorphous computing has been used both as a programming paradigm using traditional hardware, and as the basis for "cellular computing".

Nature as Implementation Substrate

All the previously described computational techniques have been implemented until now mostly on traditional electronic hardware. An entirely distinct category is that of computing paradigms that use a radically different type of "hardware".

This category includes molecular computing and quantum computing.

Molecular computing (known also as biomolecular computing, biocomputing, biochemical computing, DNA computing) is based on the idea that data can be encoded as biomolecules – such as DNA strands, and molecular biology tools can be used to transform this data to perform, for example, arithmetic or logic operations. The birth of this field was the 1994 breakthrough experiment by Leonard Adleman who solved a small instance of the Hamiltonian Path Problem solely by manipulating DNA strands in test-tubes.

There are many possible DNA bio-operations that one can use for computations, such as: cut-and-paste operations achievable by enzymes, synthesizing desired DNA strands up to a certain length, making exponentially many copies of a DNA strand, and reading-out the sequence of a DNA strand. These bio-operations and the Watson-Crick complementarity binding have all been used to control DNA computations and DNA robotic operations. While initial experiments solved simple instances of computational problems, more recent experiments tackled successfully sophisticated computational problems, such as a 20-variable instance of the 3-Satisfiability-Problem. The efforts towards building an autonomous molecular computer include implementations of computational state transitions with biomolecules, and a DNA implementation of a finite automaton with potential applications to the design of smart drugs.

More importantly, since 1994, research in molecular computing

has gained several new dimensions. One of the most significant achievements of molecular computing has been its contribution to the massive stream of research in nanosciences, by providing computational insights into a number of fundamental issues. Perhaps the most notable is its contribution to the understanding of self-assembly, which is among the key concepts in nanosciences. Recent experimental research into programmable molecular-scale devices has produced impressive self-assembled DNA nanostructures, such as cubes, octahedra, Sierpinski triangles, DNA origami, or intricate nanostructures that achieve computation such as binary counting. Other experiments include the construction of DNA-based logic circuits, and ribozymes that can be used to perform logical operations and simple computations. In addition, an array of ingenious DNA nanomachines were built with potential uses to nanofabrication, engineering, and computation: molecular switches that can be driven between two conformations, DNA "tweezers", DNA "walkers" that can be moved along a track, and autonomous molecular motors.

A significant amount of research in molecular computing has been dedicated to the study of theoretical models of DNA computation and their properties. Studies on the computational power of such models proved that various subsets of bio-operations can achieve the computational power of a Turing machine, showing thus that molecular computers are in principle possible.

Quantum Computing is another paradigm that uses an alternative "hardware" for performing computations. The idea of a quantum computer that would run according to the laws of quantum physics and operate exponentially faster than a deterministic electronic computer to simulate physics, was first suggested by Feynman in 1982. Subsequently, Deutsch introduced a formal model of quantum computing using a Turing machine formalism, and described a universal quantum computer.

A quantum computer uses distinctively quantum mechanical phenomena, such as superposition and entanglement, to perform operations on data stored as quantum bits (qubits). A qubit can hold a 1, a 0, or a quantum superposition of these. A quantum computer operates by manipulating those qubits with quantum logic gates.

The 1980s saw an abundance of research in quantum information processing, such as applications to quantum cryptography, which, unlike its classical counterpart, is not usually based on the complexity of computation, but on the special properties of quantum information. Recently, an open air experiment was reported in quantum cryptography (not involving optical cable) over a distance of 144 km, conducted between two Canary islands.

The theoretical results that catapulted quantum computing to the forefront of computing research were Shor's quantum algorithms for factoring integers and extracting discrete logarithms in polynomial time, obtained in 1994 – the same year that saw the first DNA computing experiment by Adleman. A problem where quantum computers were shown to have a quadratic time advantage when compared to classical computers is quantum database search. Possible applications of Shor's algorithm include breaking RSA exponentially faster than an electronic computer. This joined other exciting applications, such as quantum teleportation (a technique that transfers a quantum state, but not matter or energy, to an arbitrarily distant location), in sustaining the general interest in quantum information processing.

So far, the theory of quantum computing has been far more developed than the practice. Practical quantum computations use a variety of implementation methods such as ion-traps, superconductors, nuclear magnetic resonance techniques, to name just a few. To date, the largest quantum computing experiment uses liquid state nuclear magnetic resonance quantum information processors that can operate on up to 12 qubits.

Nature as Computation

Systems biology takes a systemic approach in focusing on the interaction networks themselves, and on the properties of the biological systems that arise because of these interaction networks. Hence, for example, at the cell level, scientific research on organic components has focused strongly on four different interdependent interaction networks, based on four different "biochemical toolkits": nucleic acids (DNA and RNA), proteins, lipids, carbohydrates, and their building blocks.

Gene interactions, together with the genes' interactions with other substances in the cell, form the most basic interaction network of an organism, *the gene regulatory network*. Gene regulatory networks perform information processing tasks within the cell, including the assembly and maintenance of the other networks. Research into modeling gene regulatory networks includes qualitative models such as random and probabilistic Boolean networks, asynchronous automata, and network motifs.

Another point of view, is that the entire genomic regulatory system can be thought of as a computational system, the "genomic computer". Such a perspective has the potential to yield insights into both computation as humans historically designed it, and computation as it occurs in nature. There are both similarities and significant differences between the genomic computer and an electronic computer. Both perform computations, the genomic computer on a much larger scale. However, in a genomic computer, molecular transport and movement of ions through electrochemical gradients replace wires, causal coordination replaces imposed temporal synchrony, changeable architecture replaces rigid structure, and communication channels are formed on an as-needed basis. Both computers have a passive memory, but the genomic computer does not place it in an *a priori* dedicated and rigidly defined place; in addition, the genomic computer has a dynamic memory

in which, for example, transcriptional subcircuits maintain given regulatory states. In a genomic computer robustness is achieved by different means, such as by rigorous selection: non(or poorly)-functional processes are rapidly degraded by various feedback mechanisms or, at the cell level, non(or poorly)-functional cells are rapidly killed by apoptosis, and, at the organism level, non (or poorly)-functional organisms are rapidly outcompeted by more fit species. Finally, in the case of a genomic computer, the distinction between hardware and software breaks down: the genomic DNA provides both the hardware and the digital regulatory code (software).

While systems biology studies complex biological organisms as integrated wholes, *synthetic biology* is an effort to engineer artificial biological systems from their constituent parts for the purpose of understanding natural phenomena, or for a variety of possible applications. The mantra of synthetic biology is that one can understand only what one can construct. In this sense, one can make an analogy between synthetic biology and computer engineering.
Advances in DNA synthesis of longer and longer strands of DNA are paving the way for the construction of synthetic genomes with the purpose of building an entirely artificial organism. Progress includes the generation of a 5,386 bp synthetic genome of a virus, by rapid (14 day) assembly of chemically synthesized short DNA strands.
Besides systems biology that tries to understand biological organisms as networks of interactions, and synthetic biology that seeks to engineer and build artificial biological systems, another approach to understanding nature as computation is the research on computation in living cells. This is also sometimes called *cellular computing*, or *in vivo* computing, and one particular study in this area is that of the computational capabilities of gene assembly in unicellular organisms called ciliates.
The process of gene assembly is fascinating from both the biological and the computational point of view. From the computational point of view, this study led to many novel and challenging research themes. It was proved that various models of gene assembly have full Turing machine capabilities. From the biological point of view, the joint effort of computer scientists and biologists led to a plausible hypothesis (supported already by some experimental data) about the "bioware" that implements the process of gene assembly, which is based on the new concept of template-guided recombination.
Other approaches to cellular computing include developing of an *in vivo* programmable and autonomous finite-state automaton within E.Coli, and designing and constructing *in*

vivo cellular logic gates and genetic circuits that harness the cell's existing biochemical processes.

Natural sciences: Ours to Discover

Science advances in ever-widening circles of knowledge. Sometimes it meticulously crawls. Other times it leaps to a new dimension of understanding and, in the process, it reinvents itself. As the natural sciences are rapidly absorbing ideas of information processing, and the meaning of computation is changing as it embraces concepts from the natural sciences, we have the rare privilege to take part in such metamorphoses.

At this moment natural scientists are awash in wave after gigantic wave of experimental biological data. Just underneath this tumultuous surface lie ingenious algorithms waiting to be designed, elegant theorems waiting to be proven, natural laws waiting to be discovered that will put order into chaos. For, as Spinoza wrote, "nothing happens in nature that does not follow from her laws".

Conversely, there is an abundance of natural phenomena which can inspire computing paradigms, alternative physical substrates on which to implement computations, while viewing various natural processes as computations has become more and more essential, desirable, and inevitable. All these developments are challenging our assumptions about computation, and indeed, our very definition of it. In these times our task is to discover a new, broader, notion of computation, and to understand the world around us in terms of information processing.

Notes:

Stanislaw Ulam – a mathematician, together with John von Neumann discovered a concept of a cellular automaton in the 1940s

John von Nemann – a mathematician, physicist, and polymath, contributed to the development of computing

Warren McCulloch(a neurophysiologist) and Walter Pitts(a logician) – in 1943 proposed the first model of an artificial

neuron
A cellular automaton – a collection of "colored" cells on a grid that evolves through a number of steps according to a set of rules
Ab initio – a Latin term meaning "from the beginning"
In silico – is coined as an analogy to the Latin phrases, means "performed on a computer or via a computer simulation"
A priori – a Latin expression meaning "the truth independent of experience"
DNA – deoxyribonucleic acid, a molecule that encodes the genetic instructions
Hamiltonian Graph Problem – comes from graph theory, it is a special case of a travelling salesman problem
Sierpinski triangle – a fractal with a shape of an equilateral triangle, subdivided into smaller equilateral triangles
In vivo – a Latin term, means "experimentation using a whole living organism"
E.Coli – a rod-shaped bacterium constituting about 0.1% of gut flora

Exercises

1.Give Russian equivalents to the following words and phrases and explain them in your own words:

Robustness; the former...the latter; nature-inspired models; to study extensively; to draw the inspiration from...; to gain momentum; to be referred to as...; combinatorial optimization problems; to perform... in a highly parallel fashion; a distinction between self and nonself cells; the pioneers of artificial life; a nested hierarchical structure; a membrane enveloped region; a breakthrough experiment; the Watson-Crick complementarity binding; a computational insight into some fundamental issues.

2. Translate the sentences into Russian paying attention to prefixes and suffixes:

1. Despite the relentless, breathtaking advances in computing

and related technologies, we continue to be humbled by the variety, **adaptability**, and **sophistication** of the natural world around us.

2. **Biologically inspired computing** is a field that links various disciplines such as artificial intelligence, evolutionary computation, biorobotics, artificial life, and **agent-based systems.**

3. Natural computing is a highly **interdisciplinary** field that connects the natural sciences with computing science.

4. *Genetic algorithms* are today modified heavily for applications to **real-valued** parameter optimization problems as well as **permutation-based** problems.

5. Particle Swarm Optimization algorithms have been used to solve various optimization problems, and have been applied to **unsupervised** learning.

6. Physical robots were **materializations** of their virtually evolved computational **counterparts**.

7. The field of Artificial Life continues to explore directions such as artificial chemistry, as well as traditionally-biological phenomena in artificial systems, ranging from **co-evolutionary** adaptation and development to growth, **self-replication**, and **self-repair.**

8. A generic membrane system is essentially a **nested hierarchical** structure of **cell-like** compartments or regions, **delimited** by "membranes".

9. There are many possible DNA bio-operations that one can use for computations, such as: **cut-and-paste** operations **achievable** by enzymes, s**ynthesizing** desired DNA strands up to a certain length, making **exponentially** many copies of a DNA strand, and **reading-out** the sequence of a DNA strand.

3. Give English equivalents to the following words and phrases:

...Увеличивалось разделение; в сущности...; подробно изучать; параметры, принимающие действительные значения; составление расписания; непредвиденные изменения; распознавание своих и не своих клеток;

цепочки ДНК; самый заметный; самосборные структуры; впоследствии; оттеснять на второй план; составные части; правдоподобная гипотеза; скрупулезный; быстро впитывать идеи.

4. Answer the following questions:

1. What does biologically inspired computing investigate?
2. What are the three branches of evolutionary system and what are their modern applications?
3. How can swarm intelligence contribute to the development of unsupervised learning?
4. Why is it possible to use amorphous computing as a basis of “cellular computing”?
5. What ideas underlie the development of molecular computing?
6. How does molecular computing contribute to the research in nanosciences, namely, self-assembly?
7. What are the possible quantum computer applications?
8. What are the chief similarities and differences between genomic computer and an electronic computer?
9. Is there a principal difference between systems biology and synthetic biology in terms of biological systems study?

5. Translate from Russian into English:

Эволюционные вычисления, синонимом которых в зарубежной литературе является термин *«evolutionary computation»*, доказали свою эффективность как при решении трудноформализуемых задач искусственного интеллекта (распознавание образов, кластеризация, ассоциативный поиск), так и при решении трудоемких задач оптимизации, аппроксимации, интеллектуальной обработки данных. К преимуществам эволюционных вычислений относятся адаптивность, способность к обучению, параллелизм, возможность построения гибридных интеллектуальных систем на основе комбинирования с парадигмами искусственных нейросетей и нечеткой логики. Многообещающей выглядит предпосылка создания единой концепции эволюционных вычислений, включающих генетические алгоритмы, генетическое программирование, эволюционные стратегии и эволюционное программирование. По мнению многих исследователей, эти парадигмы являются аналогами процессов, происходящих в живой природе и на практике доказавших свою непримитивность.

Один из пионеров эволюционных вычислений Л.Фогель вообще видит теорию эволюции и самоорганизации как базовую концепцию для всех интеллектуальных процессов и систем, значительно расширяющую сферу применения традиционной парадигмы искусственного интеллекта. Даже если это не так, и в природе происходит реэволюция, никто не может сказать, что алгоритмы эволюционных вычислений неверны.

6. Summarize the text and express your own opinion. Here are some possible statements to support:

1. A closer look at nature from the point of view of information processing can and will change what we mean by computation.
2. Bio-inspired algorithms can exhibit strength through flexibility: they often work well even when the desired task is poorely defined, adapt to unforeseen changes in the task environment, or achieve global behavior through interaction among many, simply programmed agents.
3. Ant algorithms are used to solve mainly combinatorial optimization problems defined over discrete search spaces.
4. So far, the theory of quantum computing has been far more developed than the practice.
5. Data can be encoded as biomolecules – such as DNA strands, and molecular biology tools can be used to transform this data to perform, for example, arithmetic or logic operations.

Challenges of Artificial Intelligence

Words and phrases:

Artificial Intelligence	– искусственный интеллект
To percieve	– понимать, воспринимать
Insight	- проницательность
Cognitive science	- познавательная наука
To overlap	- совмещать
Fuzzy systems	– нечеткая система
Biologically inspired	- на основе биотехнологий
Acute problem	- острая проблема
Critical inference	- критически важный вывод
Bias	- необъективность, предвзятость
To underestimate	- недооценить
Fallacy	- заблуждение, ложный вывод
Oft-committed	- часто совершаемый
Quantifier	- квантор
Palatable	- привлекательный, удобоваримый
To diverge	- расходиться, разниться
From scratch	- с нулевого уровня, с начала
To hone skills and knowledge	- доводить опыт и знания до совершенства
Threshold of criticality	- порог критичности
Downright	- явный, откровенный
To pose requirements	- накладывать требования
Vulnerability	- уязвимость
An endangered species	- вымирающий вид
To hard-wire	- подключить через провод

The modern definition of *artificial intelligence (AI)* is " the study and design of intelligent agents”, where an intelligent agent is a system that perceives its environment and takes actions which maximizes its chances of success.

John McCarthy (Sept.4, 1927 – Oct.24 2011), who was one of the founding pioneers of AI and also coined the very name of the field, defines it as “the science and engineering of making intelligent machines”. Other names of the field have been proposed, such as computational intelligence, synthetic intelligence or computational rationality.

The term artificial intelligence is also used to describe a property of machines or programs: the intelligence that the system demonstrates. AI research uses tools and insights from many fields, including computer science, psychology, philosophy, neuroscience, cognitive science, linguistics, operations research, economics, control theory, probability, optimization, and logic.

AI research also overlaps with tasks such as robotics, control systems, scheduling, data mining, logistics, speech recognition, facial recognition and many others.

Subjects in AI, or computational intelligence, as defined by IEEE Computational Intelligence Society mainly include: *neural networks* – trainable systems with very strong pattern recognition capabilities; *fuzzy systems* – techniques for reasoning under uncertainty (widely used in modern industrial and consumer product control systems, capable of working with concepts such as 'hot', 'cold', 'warm', and 'boiling'); *evolutionary computation* – applies biologically inspired concepts such as populations, mutation and survival of the fittest to generate increasingly better solutions to the problems.

These methods most notably divide into evolutionary algorithms (e.g., genetic algorithms) and *swarm intelligence* (e.g., ant algorithms). With hybrid intelligent systems, attempts are made to combine these two groups.

By far the greatest danger of Artificial Intelligence is that people conclude too early that they understand it. Of course, this problem is not limited to the field of AI. Jacques Monod wrote: “A curious aspect of the theory of evolution is that everybody thinks he understands it”. The problem seems to be unusually acute in Artificial Intelligence. The field of AI has a reputation for making huge promises and then failing to deliver on them. Most observers conclude that AI is hard; as indeed it is. But the embarrassment does not stem from the difficulty. It is difficult to build a star from hydrogen, but the field of stellar astronomy does not have a terrible reputation for promising to build stars and then failing. The critical inference is *not* that AI is hard, but that, for some reason, it is very easy for people to think they know far more about Artificial Intelligence than they actually do.

Anthropomorphic Bias

When something is universal enough in our everyday lives, we take it for granted to the point of forgetting it exists.

In every known culture, humans experience joy, sadness, disgust, anger, fear, and surprise and indicate these emotions using the same facial expressions. We all run the same engine under our hoods, though we may be painted different colors; a principle which evolutionary psychologists call the *psychic unity of humankind*. This observation is both explained and required by the mechanics of evolutionary biology. We humans forget how alike we are, living in a world that only reminds us of our differences. Not surprisingly, human beings often "anthropomorphize"— expect humanlike properties of that which is not human. When we try to reason about other minds, each step in the reasoning process may be contaminated by assumptions so ordinary in human experience that we take no more notice of them than air or gravity.

Anyone seeking to reduce anthropomorphic bias in themselves would be well-advised to study evolutionary biology for practice, preferably evolutionary biology with math. Early biologists often anthropomorphized natural selection—they believed that evolution would do the same thing they would do; they tried to predict the effects of evolution by putting themselves "in evolution's shoes." The result was a great deal of nonsense. Any two AI designs might be less similar to one another than you are to a petunia. The term "Artificial Intelligence" refers to a vastly greater *space of possibilities* than does the term "*Homo sapiens*." When we talk about "AIs" we are really talking about *minds-in-general*, or optimization processes in general.

The researchers believe the AI will be friendly, with no strong visualization of the exact processes involved in producing friendly behavior, or any detailed understanding of what they mean by friendliness.

Underestimating the power of intelligence implies a proportional underestimate of the potential impact of Artificial Intelligence, which is symmetrical around potential good impacts and potential bad impacts.

Capability and Motive

There is a fallacy oft-committed in discussion of Artificial Intelligence, especially AI of superhuman capability.

The following chains of reasoning, considered in isolation without supporting argument, all exhibit this fallacy:

· A sufficiently powerful Artificial Intelligence could overwhelm any human resistance and wipe out humanity. (And the AI would decide to do so.) Therefore, we should not build AI.

· A sufficiently powerful AI could develop new medical technologies capable of saving millions of human lives. (And the AI would decide to do so.) Therefore, we should build AI.

· Once computers become cheap enough, the vast majority of jobs will be performable by Artificial Intelligence more easily than by humans. A sufficiently powerful AI would even be better than us at math, engineering, music, art, and all the other jobs we consider meaningful. (And the AI will decide to perform those jobs.)

Thus after the invention of AI, humans will have nothing to do, and we'll starve or watch television.

The temptation is to ask what "AIs" will "want," forgetting that the space of minds-in-general is much wider than the tiny human dot. One should resist the temptation to spread quantifiers over all possible minds. Storytellers spinning tales of the distant and exotic land called Future, say how the future *will be*. They make *predictions*. They say,"AIs will attack humans with marching robot armies" or "AIs will invent a cure for cancer." They do not propose complex relations between initial conditions and outcomes — that would lose the audience. But we need relational understanding to manipulate the future, steer it into a region palatable to humankind. If we do not steer, we run the danger of ending up where we are going.

The critical challenge is not to predict that "AIs" will attack humanity with marching robot armies, or alternatively invent a cure for cancer. The task is not even to make the prediction for an arbitrary individual AI design. Rather the task is choosing into existence some particular powerful optimization process whose beneficial effects can legitimately be asserted.

Natural selection isn't friendly, nor does it hate you, nor will it leave you alone. Evolution cannot be so anthropomorphized, it does not work like you do. Many pre-1960s biologists expected natural selection to do all sorts of nice things, and rationalized all sorts of elaborate reasons why natural selection would do it. They were disappointed, because natural selection itself did not start out knowing that it wanted a humanly-nice result, and then rationalize elaborate ways to produce nice results using selection pressures. Thus the events in Nature were outputs of causally different process from what went on in the pre-1960s biologists' minds, so that prediction and reality diverged.

Technical Failure and Philosophical Failure

We can divide potential failures of attempted Friendly AI into two informal fuzzy categories, *technical failure* and *philosophical failure*. Technical failure is when you try to build an AI and it doesn't work the way you think it does — you have failed to understand the true workings of your own code. Philosophical failure is trying to build the wrong thing, so that even if you succeeded you would still fail to help anyone or benefit humanity. Needless to say, the two failures are not mutually exclusive.

In place of laws constraining the behavior of intelligent machines, we need to give them emotions that can guide their learning of behaviors. They should want us to be happy and prosper, which is the emotion we call love. We can design intelligent machines so their primary, innate emotion is unconditional love for all humans. First we can build relatively simple machines that learn to recognize happiness and unhappiness in human facial expressions, human voices and human body language. Then we can hard-wire the result of this learning as the innate emotional values of more complex intelligent machines, positively reinforced when we are happy and negatively reinforced when we are unhappy. Machines can learn algorithms for approximately predicting the future, so we can program intelligent machines to learn algorithms for predicting future human happiness, and use those predictions as emotional values.

A technical failure occurs when the code does not do what you think it does, though it faithfully executes as you programmed it. Suppose we trained a neural network to recognize smiling human faces and distinguish them from frowning human faces. Would the network classify a tiny picture of a smiley-face into the same attractor as a smiling human face?

This form of failure is especially dangerous because it will appear to work within a fixed context, then fail when the context changes.

Suppose we wish to develop an AI of increasing power. The AI possesses a developmental stage where the human programmers are more powerful than the AI, smarter, more creative, more cunning than the AI. During the developmental period we suppose that the programmers possess the ability to make changes to the AI's source code without needing the consent of the AI to do so. However, the AI is also intended to possess postdevelopmental stages, including superhuman intelligence. An AI of superhuman intelligence surely could not be modified without its consent. At this point we must rely on the previously laid-down goal system to function correctly, because if it operates in a sufficiently unforeseen fashion, the AI may actively resist our attempts to correct it — and, if the AI is smarter than a human, probably win.

Trying to control a growing AI by training a neural network to provide its goal system faces the problem of a huge context change between the AI's developmental stage and postdevelopmental stage. During the developmental stage, the AI may only be able to produce stimuli that fall into the "smiling human faces" category, by solving humanly provided tasks, as its makers intended. Thus the AI appears to work fine during development, but produces catastrophic results after it becomes smarter than the programmers.

One of the most critical points about Artificial Intelligence is that it might increase in intelligence extremely fast. The obvious reason to suspect this possibility is recursive self-improvement. The AI becomes smarter, including becoming smarter at the task of writing the internal cognitive functions of an AI, so the AI can rewrite its existing cognitive functions to work even better, which makes the AI still smarter, including smarter at the task of rewriting itself, so that it makes yet more improvements.

Human beings do not recursively self-improve in a strong sense. To a limited extent, we improve ourselves: we learn, we practice, we hone our skills and knowledge. To a limited extent, these self-improvements improve our ability to improve. New discoveries can increase our ability to make further discoveries— in that sense, knowledge feeds on itself. But there is still an underlying level we haven't yet touched. We haven't rewritten the human brain. The brain is, ultimately, the source of discovery, and our brains today are much the same as they were ten thousand years ago.

An Artificial Intelligence could rewrite its code from scratch. The key implication for our purposes is that an AI might make a huge jump in intelligence after reaching some threshold of criticality.

An often heard reaction "We don't need to worry about Friendly AI because we don't yet have AI," is misguided or downright suicidal. The mathematics and techniques of Friendly AI will not materialize from nowhere when needed; it takes years to lay firm foundations. And we need to solve the Friendly AI challenge before Artificial General Intelligence is created, not afterward.

The possibility of sharp jumps in intelligence also implies a higher standard for Friendly AI techniques. The technique cannot assume the programmers' ability to monitor the AI against its will, rewrite the AI against its will, bring to bear the threat of superior military force; nor may the algorithm assume that the programmers control a "reward button" which a smarter AI could wrest from the programmers; etc. Indeed no one should be making these assumptions, to begin with. The indispensable protection is an AI that does not *want* to hurt you.

Conclusion

Modern civilization occupies an unstable state. Pragmatically speaking, our alternatives boil down to becoming smarter or becoming extinct. Nature is not cruel, but indifferent; a neutrality which often seems indistinguishable from outright hostility. Reality throws at you one challenge after another, and when you run into a challenge you can't handle, you suffer the consequences. Often Nature poses requirements that are grossly unfair, even on tests where the penalty for failure is death. Nature does not match her challenges to your skill, or your resources, or how much free time you have to think about the problem. And when you run into a lethal challenge too difficult for you, you die. It may be unpleasant to think about, but that has been the reality for humans, for thousands upon thousands of years. The same thing could as easily happen to the whole human species, if the human species runs into an unfair challenge.

To survive any appreciable time, we need to drive down each risk to nearly zero. But the human mind is not the limit of the possible. *Homo sapiens* represents the first general intelligence. We were born into the uttermost beginning of things, the dawn of mind. With luck, future historians will look back and describe the present world as an awkward in-between stage of adolescence, when humankind was smart enough to create tremendous problems for itself, but not quite

smart enough to solve them.
Yet before we can pass out of that stage of adolescence, we must, as adolescents, confront an adult problem: the challenge of smarter-than-human intelligence. This is the way out of the high-mortality phase of the life cycle, the way to close the window of vulnerability; it is also probably the single most dangerous risk we face. Artificial Intelligence is one road into that challenge; and it is the road we will end up taking.
All scientific ignorance is hallowed by ancientness. Each and every absence of knowledge dates back to the dawn of human curiosity; and the hole lasts through the ages, seemingly eternal, right up until someone fills it. It is possible for mere fallible humans to succeed on the challenge of building Friendly AI. Intelligence must cease to be any kind of mystery whatever, sacred or not. We must execute the creation of Artificial Intelligence as the exact application of an exact art. And maybe then we can win.
In April 2000, Bill Joy, the technologists' technologist, wrote an article entitled “Why the Future Doesn't Need Us” for *Wired* magazine. “Our most powerful technologies – robotics, genetic engineering, and nanotech – are threatening to make humans an endangered species,” he wrote. In August 2011 Jaron Lanier, another widely respected technologist, wrote about the impact of AI on the job market. In the non-too-far future, he predicted, it would just be inconceivable to put a person behind a wheel of a truck or a cab. Machines will be capable of doing any work a man can do. AI has been proven to be much more difficult than early pioneers believed. Bill Joy's question deserves not to be ignored. *Does the future need us?*

Notes:

IEEE Computational Intelligence Society – a professional society that focuses on theory, design, application and development of neural systems, genetic algorithms, bioinformatics, and hybrid intelligent systems.
John McCarthy – an American computer and cognitive

scientist who coined the term “Artificial Intelligence”.
Swarm intelligence – the collective behavior of decentralized, self-organized systems, natural or artificial (ant colonies, bird flocking, bacterial growth, etc.).
Anthropomorphism – an attribution of a human form or other characteristics to anything other than a human being.
***Wired* (magazine)** – a full-color monthly American magazine, published in both printed and online editions, that reports how emerging technologies affect culture, economy, and politics.

Exercises

1. Give Russian equivalents to the following words and phrases and explain them in your own words:
To overlap; trainable systems; fuzzy systems; an acute problem; to stem from...; stellar astronomy; to take for granted; to anthropomorphize; an anthropomorphic bias; to put oneself in one's shoes; to underestimate; oft-committed fallacy; to overwhelm human resistence; the vast majority; a palatable region; a beneficial effect; prediction and reality diverged; to rationalize ways to produce nice results; an innate emotion; to hard-wire the result; a goal system.

2. Translate the sentences into Russian paying attention to prefixes and suffixes:
1. **Neural** networks are **trainable** systems with very strong pattern recognition capabilities.
2. Human beings often **“anthropomorphize”**— expect **humanlike** properties of that which is not human.
3. **Underestimating** the power of intelligence implies a proportional **underestimate** of the potential impact of Artificial Intelligence, which is symmetrical around potential good impacts and potential bad impacts.
4. There is a fallacy **oft-committed** in discussion of Artificial Intelligence, especially AI of **superhuman** capability.
5. We need relational understanding to manipulate the future, steer it into a region **palatable** to humankind.

6. The AI is intended to possess **postdevelopmental** stages, including **superhuman** intelligence.
7. Artificial Intelligence might increase in intelligence through **recursive self-improvement.**
8. Nature is not cruel, but **indifferent; a neutrality** which often seems **indistinguishable** from **outright** hostility.

3. Give English equivalents to the following words and phrases:
Основатели ИИ; испытывать радость; дружественный ИИ; цепочки рассуждений; противостоять искушению; направлять будущее; естественный отбор; предсказания и реальность разнятся; изобретательный программист; сформулировать цель; саморазвитие; переписать с нуля; достичь критического порога; прочное основание; совершенно необходимая защита; изложить требования.

4. Answer the following questions:
1. What are the subjects in AI?
2. What is the most acute problem in AI?
3. Why do people often “anthropomorphize”?
4. How should natural selection and evolution be considered by scientists?
5. What are the potential failures of attempted Friendly AI?
6. Is there a conflict between developmental and postdevelopmental stages of AI improvement?
7. Is it possible to overcome the challenge of smarter-than-human intelligence?
8. Does the future need us?

5. Translate from Russian into English:
В 1950г. британский математик и криптограф Алан Тьюринг выпустил статью «Вычислительные машины и разум», заложив краеугольный камень в отрасль, которая занимается разработкой искусственного интеллекта. Тьюринг предложил решить проблему практически, а не теоретически, - с помощью теста.

Если человек в ходе переписки с программой не может определить, человек его собеседник или машина, то следует признать эту программу разумной, что бы это ни значило.
В этом году в конкурсе должны были участвовать шесть программ: Alice, Brother Jerome, Elbot, Eugene Goostman, Jabberwacky и Ultra Hal. Самой умной была признана программа Elbot – ей удалось одурачить трех из 12 судей, то есть 25%.
Тест Тьюринга проходят программы, которые имитируют поддержание беседы, а не ведут ее. В разговорах с ними бесполезно искать новую для себя информацию. В большинстве случаев они пытаются свести конкретные вопросы к общим ответам. Такой была одна из первых программ, попытавшихся пройти тест Тьюринга, ELIZA. Она реагировала на ключевые слова и высказывала свое мнение по данному вопросу. Ее суждения не выходили за рамки, жестко заданные программистом.
С тех пор искусство имитации продвинулось далеко вперед. Одна из программ, например, в разговоре постоянно упоминала тетю Соню из Одессы, другая — намеренно шутила о себе как о роботе, чтобы сбить людей с толку. Сам автор Elbot не считает, что его программа хоть как-то может мыслить. Он сравнивает ее беседы с фокусами, у которых есть секрет, но не более.

6. Develop the following ideas in writing an essay (120 – 150 words):

1. The greatest danger of AI is that people conclude too early that they undertstand it.
2. One of the most critical points about AI is that it might increase in intelligence extremely fast.
3. Our alternatives boil down to becoming smarter or becoming extinct.

Nanoscience: Facts vs. Fiction

Words and Phrases:

Dissipation – рассеивание
Robust – надёжный, устойчивый к ошибкам
Resilience - устойчивость(к внешним воздействиям)
Intrinsically – по сути, в сущности
Speculation – предположение, догадка,
Constraint – ограничение
To shrink – уменьшаться, сокращаться
A fabric – строение, структура
Bandwidth – ширина спектра; диапазон рабочих частот
Heterogeneous – неоднородный
To be embedded – быть внедренным
Performance gap – разница в исполнении
Merging - слияние, объединение
In the interim – пока что, тем временем
Soft-error – программная ошибка
Overhead – издержки, затраты
Synergy – взаимное усиление
Error-prone – склонный к ошибкам
To garble - искажать
Plausibility – правдоподобие
Intestine - кишечник
Feasible - правдоподобный

There has been a great deal of public and scientific interest in the so-called nanotechnology revolution. Nanotechnology can be defined as the manipulation, precision placement, measurement, modeling, or manufacture of sub-100 nanometer (nm) scale matter (lnm equals 1/1,000,000,000* of m). This manipulation of matter at the nano level will greatly influence most areas of our life, such as manufacturing, engineering, health, pharmaceuticals, and (of special interest here) information technology. There is a wide range of nanoparticles of different types and different properties currently in production that may be applied in a variety of ways. It is envisaged that nanoparticle types found useful will be further developed by large-scale production.

Architectures for Silicon Nanoelectronics and Beyond

The semiconductor industry faces serious problems with power density, interconnect scaling, defects and variability, performance and density overkill, design complexity, and memory-bandwidth limitations. A candidate to replace complementary metal-oxide semiconductor (CMOS) technology, nanoelectronics could address some of these challenges, but it also introduces new problems. Molecular-scale computing will likely allow additional orders-of-magnitude improvements in device density and complexity.

The effective use of nanotechnology will require not just solutions to increased density, but total system solutions. We can't develop an architecture without a sense of the applications it will execute. And any paradigm shift in applications and architecture will have a profound effect on the design process and tools required.

We define *nanoarcbitecture* as the organization of basic computational structures composed of nanoscale devices assembled into a system that computes something useful. Nanoarchitecture will enable radically different computational models, and, due to its potential for large capacity, might also provide superior capabilities in some areas.

There are two paths to follow: evolutionary and revolutionary.

Evolutionary path. Silicon semiconductor technology will continue to shrink. But there's an increasing performance gap between device technology and its ability to deliver performance in proportion to device density. Performance, in terms of millions of instructions per second per watt, isn't keeping up with the increase in millions of devices per chip. There's also a gap between device density and our ability to design new chips that use every device on the chip and guarantee they're designed correctly. Power consumption and heat dissipation present additional challenges.

Revolutionary path. Knowing that the end of Moore's law scaling is in sight for traditional silicon technology, many have embarked on revolutionary nanoelectronics research. Researchers are studying carbon nanotube transistors, carbon nanotube memory devices, molecular electronics, spintronics, quantum-computing devices, magnetic memory devices, and optoelectronics.

Unfortunately, we won't use many of these devices until it's absolutely necessary to consider a replacement technology. So, how should we use these revolutionary nanoelectronic devices in the interim, especially when these devices haven't demonstrated sufficient reliability and large enough signal-to-noise ratio to guarantee reliable digital computation?

In addition to massive CMOS-scaling efforts, many researchers are pursuing molecular, optical, or quantum devices that they could integrate with CMOS-based digital logic to produce hybrid systems.

Hybrid architectures will allow integration of sensing and processing functions in ways analogous to biological systems. Living beings can perform complex real-time functions with remarkable ease, unmatched in performance by the most powerful man-made computers. Inspired by biology, cellular sensor-processor architectures appear promising for hybrid nanodevices.

The availability of very dense conventional silicon technology, along with non-conventional, nanoscale storage or memory technology based on phase-changing materials, also makes fascinating hybrid architectures possible.

Integration of logic and memory will allow large-scale array computing with increased local storage. This is, incidentally, an important operating principle of neural circuits. Relevant work in this area includes the Intelligent RAM project at the University of California, Berkeley.

In addition to logic and memory, hybrid architectures might allow for integration of sensing with logic and memory. One important class of applications would be vision systems, in which each photo detector would be embedded with its own circuitry in a cellular architecture. Each element in such an architecture would resemble a "neuron" in a retina-like array, where the system performs basic image-processing functions on the incoming image flow.

Similarly, other biologically inspired applications include speech or auditory processing. The human auditory system can recognize speech even if it's garbled, embedded in noise, or mixed with other voices. Here, in addition to dense memories and massively parallel processing, nanoelectronics offers the potential for combining the sensing of sound and the processing of speech into a single computational nanoarchitecture.

Risks of Nanotechnology

With all the excitement over the potential of nanotechnology, has any research addressed the potential toxicity nanoparticles may have on our health and environment?

Nanofiction. In his novel, *Prey,* Michael Crichton writes of a swarm of nanobots released in the Nevada desert, terrorizing the very scientists who developed them. Unfortunately, this deepening vision of "grey goo" coating our landscape as the nanobots replicate uncontrollably is the picture some people have of the risk from nanotechnology. Such a picture, though titillating, is a scientific fantasy, more in the tradition of *King Kong* than the realms of scientific plausibility. The actual risks from nanotechnology, as seen by those of us working in this field, are less dramatic, but nonetheless, are potentially real.

Nanofacts.

The greatest risk to human health and to the environment lies in this rapid expansion of different types of nanoparticles under development and the potential for their production. It brings with it the possibility of large-scale human exposure predominantly in the work place as these nanoparticles are incorporated into products of every conceivable type from IT to food. Additionally, the particles can be released during wear and destruction throughout the life of a product. Such diversity in use (with numerous potential scenarios for exposure) means that nanoparticles are likely to make contact with the body via the lungs, intestines, and skin.

The lungs are an obvious and critical route of entry to the body, especially during the manufacturing process where dust clouds can be generated. The intestines provide a route of entry for nanoparticles contained both within processed foods and in mucus cleared from the lungs. Entry of nanoparticles through the skin via cosmetics is also feasible. Recent evidence suggests that nanoparticles landing in the nose can move upward into the base of the brain. The effect this has on the brain and nervous system is under investigation.

Medical Uses of Nanoparticles

The very properties that make nanoparticles useful for new applications are also the very properties that can increase their harmfulness.

For example, it is possible to alter the surface of a nanoparticle to direct it toward a specific organ such as the liver or brain, thus allowing drugs to be targeted to a specific spot rather than working through the entire body. This is not only more efficient for the patient, but it results in fewer side effects. It suggests the way in which nanoparticles travel around the body and ultimately settle. And where do the particles go after they have fulfilled their delivery function? What effect do they have on the various organs they target?

Nanotubes are like extended buckyballs (a molecule of carbon-60); that is, they are very thin (a few tens of nm), but can be very long (in the order of mm). They are extremely strong, able to maintain their structure and not break down in the lung. Nanotubes are similar to fibers like asbestos and glass, and as such could be very harmful to the lungs causing scarring and cancer. Therefore, adequate toxicological studies of nanotubes must be conducted to fully understand the potential risks.

The scientists have recently suggested we must recognize a new science of *Nanotoxicology* to specifically examine the products of the nanotechnology revolution for their likely adverse effects. We are not suggesting that further advancement of nanotechnology, nor the development of nanoparticles, should be halted; in fact, this field promises great benefit, especially for the IT and communications industries. We only suggest that proper toxicology testing be carried out to ensure such products are being handled safely and there is no undue risk to the makers and users of nanoparticles.

Notes:

CMOS – Complementary Metal-Oxide Semiconductor
VLSI technology – Very Large-Scale Integration
RAM – random-access memory
Mucus – a slimy substance secreted by mucous membranes and glands for lubrication, protection, etc.
Grey goo – (also spelled **gray goo**) a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all matter on Earth while building more of themselves
Buckyball – a spherical fullerene which is any molecule composed entirely of carbon (as it resembles the balls used in football)
nm – nanometer

Exercises

1. Give Russian equivalents to the following phrases and explain them in your own words:

Molecular-scale; spintronics; bottleneck; optoelectronics; fault-free; cost-effective; large-scale; scientific plausibility; to replicate; conceivable; to mediate; airborne; diesel exhaust; unforeseen consequences; side effects; to halt; memory-bandwidth limitations; orders-of-magnitude improvements.

2. Translate the sentences into Russian paying attention to prefixes and suffixes:

1. The **semiconductor** industry faces serious problems with power density, **interconnect** scaling, defects and variability, performance and density **overkill**, design complexity, and memory-bandwidth limitations.
2. Others, such as **macroredundancy** in the form of **triplicate**

voting schemes, are much more expensive.
3. The unpredictability in confirmation completion and the worst-case hardware **over**head require reliable hybrid architectures, **necessitating** exploration of speculation and **adaptivity** to ensure correct computation at low hardware and time costs.
4. Since this work is **interdisciplinary**, researchers must clarify interfaces between various levels of abstraction during the tool-development process.
5. Although they've been tried several times over the years, **asynchronous self-timed** circuits and logic have limited use.
6. Unfortunately, this deepening vision of "grey goo" coating our landscape as the nanobots replicate **uncontrollably** is the picture some people have of the risk from nanotechnology.
7. There has been a great deal of public and scientific interest in the **so-called** nanotechnology revolution.
8. Another **disease-causing** dust – asbestos — might actually help us understand the risks from **nanotubes**.
9. To protect them against particles in the air, there is an **upwardly** moving carpet of mucus that traps particles.

3. Match the adjectives (1-10) in column *A* with the definitions (a-j) in column *B.*

1. stochastic	a. very large in size, quantity, or extent
2. empirical	b. working together in a creative, innovative, and productive manner
3. enormous	c. able to do tasks successfully, without wasting time or energy
4. sophisticated	d. for a short time only, temporary
5. transient	e. verifiable by observation or experience rather than theory or pure logic
6. susceptible	f. following the accepted customs; that has been in use for a long time
7. synergistic	g. randomly determined
8. efficient	h. able to be easily modified to respond to altered circumstances
9. conventional	i. liable to be influenced or harmed by a

particular thing
10. flexible j. developed to a high degree of complexity

4. Give English equivalents to the following words and phrases:

Вводить в действие новые технологии; приступить к исследованию; заниматься приборами; быть подверженным ошибкам; вероятностный; делать предположение/допущение; привести эру к завершению/окончанию; воздействие на человека; служить связующим звеном; причинять сильный вред; последствия; выбрать в качестве цели; искаженная речь; побочные эффекты

5. Answer the following questions:

1. What is nanotechnology?
2. What does CMOS stand for?
3. What is the controversial nature of nanoelectronics?
4. What is nanoarchitecture?
5.What are the evolutionary and revolutionary paths of the nanoarchitecture development?
6. What are hybrid architectures? What are their advantages?
7. What areas of human life will the nanotechnology revolution influence?
8. What are the risks to human life and the environment?
9. What are the benefits and risks of nanoparticles in medicines?
10 What is Nanotoxicology? How will it help to deal with the adverse effects of nanotechnology?

6. Fill in the blanks with the words and phrases from the article:

1. There is a wide range of nanoparticles of different types currently ... that may be applied in a variety of ways.
2. And any paradigm shift in applications and architecture will have a ... effect on the design process and tools required.

3. Living beings can perform complex real-time functions with ... ease.
4. Entry of nanoparticles through the skin via cosmetics is also ....
5. ... toxicological studies of nanotubes must be conducted to fully understand the potential risks.
6. This deepening vision of ... coating our landscape is the picture some people have of the risk from nanotechnology

7. Insert the prepositions where necessary:

1. There has been significant interest ... nanotechnology in the past few years.
2. The expansion of nanoparticles are a great risk ... human health.
3. The number of people applying for entry ... the country is increasing with every year.
4. It's not pleasant to have huge debts hanging ... your head.
5. The effect of nanoparticles on the brain and nervous system is ... investigation.
6. The process results ... come side effects.
7. Proper toxicology testing must be carried ... to ensure the safety of such products.
8. The change is not confined ... chemistry only.
9. Chemical reactions may lead ... lung injury.

8. Translate from Russian into English:

Термин «наноэлектроника» относительно новый и пришел на смену более привычному для старшего поколения термину «микроэлектроника», под которым понимали передовые для 60-х годов технологии полупроводниковой электроники с размером элементов порядка одного микрона

Однако наноэлектроника связана с разработкой архитектур и технологий производства функциональных устройств электроники с топологическими размерами элементов на порядки меньше, не превышающими 100 нм, а иногда и 10 нм.

Главной особенностью наноэлектроники является в первую очередь не простое механическое уменьшение размеров, а то, что для элементов таких размеров начинают преобладать квантовые эффекты, использование которых может стать очень перспективным.

В настоящее время пользователям доступно более 2800 видов различных приложений, в состав которых входят наночастицы, а к 2017 году ожидается, что мировой объем продаж таких приложений достигнет 50 миллиардов долларов. Однако, по мнению ученых, такой рост нанотехнологических устройств несет в себе определенный риск для здоровья населения и экологии окружающей среды.

«В типичной порошковой форме токсичность этих соединений невелика, однако в виде наночастиц с диаметром 16-80 нанометров ситуация кардинально меняется», - отметил ведущий исследователь Юэ-Вен-Хуан (Yue-Wern-Huang) из Миссурийского университета науки и технологий.

Теперь исследователи работают над возможностью снизить токсичность наночастиц и подробнее изучить механизм их взаимодействия с клетками.

9. Develop the following ideas in writing an essay (120-150 words):

1. The future of nanoelectronics: perspectives and challenges.
2. Revolutionary and evolutionary paths in the development of nanoarchitecture: advantages and disadvantages.
3. Practical applications of nanotechnologies.
4. Threats nanoparticles pose to human health.

Green Computing

Words and phrases:

Green computing	- экологичное вычисление
Sustainable computing	- устойчивое вычисление
Hazardous materials	- опасные материалы
To harness	- обуздать
Recyclability	- вторичная переработка
Biodegradability	- биоразлагаемость
Defunct and factory waste	- промышленные отходы
Conspicuous and outspoken	- заметные и откровенные
To lambast	- критиковать
Holistic approach	- целостный подход
Brainstorm approach	- мозговой штурм
Revenue	- доход
Fanciful	- причудливый
Carbon footprint	- выбросы углекислого газа
Evaporative cooling	- охлаждение путем испарения
Smart grids	- интеллектуальные сети
Ongoing effort	- постоянные усилия
Adjustments	- корректировки
Product longevity	- долговечность продукта
Trade-off	- альтернатива, компромисс
Refinements	- уточнения
Prominence	- известность
Upgradability	- модернизация
Modularity	- модульность
Hexavalent chromium	- шестивалентный хром
Retail outlets	- магазины розничной торговли
Profit margin	- коэффициент прибыли
Insomnia	- бессонница
Overhead costs	- накладные расходы

The term Green Computing or ICT refers to environmentally sustainable computing. Today, it embodies the entire life cycle of technologies, including research, manufacturing, use and disposal. In his article “Harnessing Green IT: Principle and Practices”, San Murugesan, NASA consultant and professor for Western Sydney University, defines the field of green computing as “the study and practice of designing, manufacturing, disposing of computers, servers, and associated subsystems - such as monitors, printers, storage devices, networking and communications systems - efficiently and effectively with minimal or no impact on the environment”.

The goals of green computing are sustainable innovations that include reduction of the hazardous materials, maximization of energy efficiency during the product’s lifetime, reverse of supply chain, recyclability or biodegradability of defunct and factory waste.

“The system we now employ is hugely wasteful,” says a professor of computer technology at the University of Cambridge Andy Hopper, one of the most conspicuous and outspoken pioneers in the green computing movement.

Much of the green computing movement’s focus today is on data centers, which have been lambasted as “the SUVs of the tech world “ for their enormous and wasteful consumption of electricity, accounting for between 1.1% and 1.5% of the world’s total energy use in 2010. In recent years, Microsoft and other major companies, hosting online services, need to use more and more energy for their centers. The Microsoft facility, which consumes up to 27 megawatts of energy at any given time, has built data centers in Washington to take advantage of the hydroelectric power produced by two dams in the region. Google’s data centers use half the industry’s average amount of power.

Nowadays as the companies are brainstorming solutions to cut costs and increase revenue green computing takes a much more holistic approach than before. The proposed and existing strategies now range from the practical to the fanciful, and include government regulations, industry initiatives, environmentally friendly computers made of recyclable materials.

In 2007 a global consortium of computer companies, including AMD, Dell, IBM, Sun Microsystems, and VM-ware, organized The Green Grid with the goal of improving energy efficiency in data centers and business computing systems. To achieve the goal, The Green Grid collaborates with individual companies, government agencies, and industry groups to provide recommendations on best practices, metrics, and technologies that will improve data centers' energy efficiency.

Since 2007 Dell has been accelerating its programs to reduce hazardous substances in its computers, and its new OptiPlex desktops are 50% more energy-efficient than similar systems manufactured before, thanks to more energy-efficient processors, new power management features, and other factors. Microsoft, Google, Yahoo, Japanese Jujitsu have been expressing the environmental concerns about their data centers' carbon footprint and the measure of the environmental impact of an individual or organization's lifestyle. Google, Inc. states its improved energy usage and attributes this to the cooling technologies, such as ultra-efficient evaporative cooling. "Our carbon footprint is calculated globally and includes our direct fuel use, purchased electricity, and business travel - as well as estimates for employee commuting, construction, and server manufacturing at our facilities around the world", says Google's director of energy strategy Bill Weihl. With the aid of a self-styled ultra efficient evaporative cooling technology, Google has been able to reduce its energy consumption to 50% of that of the industry average.

In 2010, the American Recovery and Reinvestment Act (ARRA) was signed into legislation by President Obama. The bill allocated over $90 billion to be invested in green initiatives (renewable energy, smart grids, energy efficiency, etc.).

Green computing today is a multifaceted, global effort to reduce consumption and provide sustainability. The list of the participating countries is expanding including at the moment the USA, China, Japan, India, Italy, Spain, Great Britain and Russia. Russia's ongoing effort to raise its investments in high performance computers to fuel the growth of its economy through energy efficiency and sustainable technology is noteworthy.

Degree and postgraduate programs provide training in a range of information technology concentrations along with sustainable strategies in an effort to educate students how to create systems reducing its negative impact on the environment. In the UK, Leeds Metropolitan University offers an MSc Green Computing program in both full and part-time access modes. The Australian National University offers "ICT Sustainability" course as part of its information technology and engineering masters programs.

In 2012 the Russian Institute of Information Technology and Telecommunication SKFU in Stavropol won a grant of the British University of Newcastle for the development of curricula and programs graduate, postgraduate and professional development courses in "Eco-friendly computer technology and communication" (Fostering innovations on Green Computing - GREENCO). The consortium of the project consists of seven universities in Russia, six Ukrainian universities, and four educational institutions of the European Union, including the University of Leads (UK), Institute of Science and Technology information (Italy), Slovakian University and the University of Loannina (Greece).

There have been a number of International Conferences (including Slovak Second Workshop in May 2013 and Belgorod Third International Workshop in November 2013) devoted to Green and Safe Computing. The main goal of the program of international cooperation - the integration of modern developments in the field of information and telecommunications in the learning process, taking into account the impact of these developments on the environment, that is, adding ecological component in the training of IT professionals and the creation of the training courses, which would preclude the negative impact on nature.

At the workshops some adjustments regarding green computing and IT support were discussed. They include: algorithmic efficiency, computer virtualization, terminal servers, operating system support, product longevity, material recycling, telecommuting, and others.

The efficiency of algorithms has an impact on the amount of computer resources required for any given computing function and there are many efficiency trade-offs in writing programs. Algorithm changes, such as switching from a slow (e.g. linear) search algorithm to a fast (e.g. hashed or indexed) search algorithm can reduce resource usage for a given task from substantial to close to zero. Algorithms can be used to route data to the data centers where electricity is less expensive. Larger server centers are sometimes located where energy and land are inexpensive and readily available. Local availability of renewable energy, climate that allows outside air to be used for cooling, or locating them where the heat they produce may be used for other purposes could be factors in green siting decisions.

The approaches to actual reduction of network devices energy consumption by proper network management techniques were also surveyed in. They were grouped into 4 main strategies: Adaptive Link Rate (ALR), Interface Proxying, Energy Aware Infrastructure, and Energy Aware Applications.

Computer virtualization refers to the abstraction of computer resources, such as the process of running two or more logical computer systems on one set of physical hardware. With virtualization, a system administrator could combine several physical systems into virtual machines on one single, powerful system, thereby unplugging the original hardware and reducing power and cooling consumption. Virtualization can assist in distributing work so that servers are either busy or put in a low-power sleep state. In order to facilitate virtual computing several commercial companies and open-source projects now offer software packages to enable virtualization enhancements to the x86 instruction set into each of their CPU product lines.

Terminal servers have also been used in green computing. When using the system, users at a terminal connect to a central server, on which computing is done. This can be combined with thin clients, which use up to1/8 amount of energy of a normal workstation, resulting in a decrease of energy costs and consumption. There has been an increase in using terminal services with thin clients to create virtual labs. Examples of terminal server software include Terminal Services for Windows and the Linux Terminal Server Project (LTSP) for the Linux operating system.

The dominant desktop operating system, Microsoft Windows, has included limited PC power management features since Windows 95. Windows 2000 was the first NT-based operating system to include power management. This required major changes to the underlying operating system architecture and a new hardware driver model. The power management system was significantly improved in Windows Vista to allow basic configuration by Group Policy. The most recent release, Windows 7 includes refinements for more efficient user of operating system timers, processor power management, and display panel brightness. The most significant change in Windows 7 is in the user experience. The prominence of the default High Performance power plan has been reduced with the aim of encouraging users to save power. Most products offer Active Directory integration and per-user/per-machine settings with the more advanced offering multiple power plans, scheduled power plans, anti-insomnia features and enterprise power usage reporting.

Product longevity. According to the company Gartner analysts the PC manufacturing process accounts for 70% of the natural resources used in the life cycle of a PC. Another report from Gartner recommends looking for product longevity, including upgradability and modularity. Manufacturing a new PC makes a far bigger ecological footprint than upgrading an existing one.

Materials recycling. Recycling computing equipment can keep harmful materials as lead, mercury, and hexavalent chromium out of landfills, and can also replace equipment, saving further energy and emissions. Additionally, parts from outdated systems may be salvaged and recycled through certain retail outlets and municipal or private recycling centers. Computing supplies, such as printer cartridges, paper, and batteries may be recycled as well.

Though the collection rate of e-waste is still very low even in the most ecology-responsible countries like France, still there are some first steps in this direction.

Hewlett-Packard recently unveiled what it calls "the greenest computer ever" – the rp557000 desktop PC. The rp5700 has an expected life of at least five years, and 90% of its materials are recyclable. The computer is easy to disassemble and meets the European Union's RoHS standards for the restriction of the use of certain hazardous substances in electrical and electronic equipment. Moreover, 24% of the rp5700's packaging materials are made of recycled material.

A drawback to many of these schemes is that computers gathered through recycling drives are often shipped to developing countries where environmental standards are less strict than in North America and Europe.

Telecommuting. In green computing initiatives teleconferencing and telepresence technologies are often implemented. There are many advantages: increased worker satisfaction, reduction of greenhouse gas emissions, related to travel, and increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc. Many types of jobs, such as sales, consulting, and field service integrate well with this technique.

"We have just started to address the issue of green computing", writes Andy Hopper in his paper "Computing for the Future of the Planet". Among the principal goals of "positive computing" he identifies an optimal digital infrastructure in which carpeting's overall energy consumption is reduced and the efficient use of energy in manufacture, operation, and disposal of computing devices is maximized. "People in the developing world often live in recourse-impoverished environments so a physical-to-digital paradigm shift has the potential to enable activities that were hitherto prohibitively expensive and to support development whilst minimizing its impact...By modeling their behaviour people can predict and respond correctly to future events", he says. Andy Hopper insists he's not a utopian, but his vision of a not-too-distant future of computing shares some resemblances with the dreams of science-fiction writers.

Notes:

IST – Information and Communication Technologies

NASA- the National Aeronautics and Space Administration Agency (founded in 1958)

SUV - Sport Utility Vehicle

CPU – Central Processing Unit

AMD – Global Provider of Innovative Graphics, Processors and Media

Dell - one of the largest corporations in the field computer production

OptiPlex – PC Dell OptiPlex

VM-ware - Big US company dealing with software for virtualization

NT Operating System (architecture) – The US multinational information Technology Corporation

RoHS - European Union's Standards adopted in 2006

Hewlett Packard – one of the largest US companies in the field of IT

Tujitsu - one of the largest Japanese companies working in IT

Friendly computers - repair and networking services for PC and Apple computers

Thin client – a computer or a computer program that depends on some other computer (its server) to fulfill its computational roles

Gartner - research and consulting company specializing in IT markets

A hashed-indexed algorithm – an indexing algorithm hash

generally used to quickly find items, using lists called "hash tables"
Rp5700 - readily recyclable packaging materials
Carpeting's overall energy - energy conservation

Exercises

1.Give Russian equivalents to the following words and phrases and explain them in your own words:

Make it green; open-source projects; hazardous substances; anti-insomnia features; keep out of land files; technique; to cut costs and increase revenue; carbon footprint; employee commuting; to sign into legislation; computer virtualization; to have an impact on...; efficiency; refinements; to meet the standards; profit margins; overhead costs.

2. Translate the sentences into Russian paying attention to the prefixes and suffixes:

1.The goals of green computing are sustainable innovations that include reduction of the hazardous materials, maximization of energy efficiency during the product's lifetime, **reverse** of supply chain, **recyclability** or **biodegradability** of defunct and factory waste.
2. Andy Hopper is one of the most conspicuous and **outspoken** pioneers in the green computing movement.
3. Green computing today is a **multifaceted**, global effort to reduce consumption and provide **sustainability**.
4. Larger server centers are sometimes located where energy and land are **inexpensive** and readily available.
5. Local availability of **renewable** energy, climate that allows outside air to be used for cooling, or locating them where the heat they produce may be used for other purposes could be factors in green decisions.
6. Google, Inc. states its improved energy usage and attributes this to the cooling technologies, such as **ultra-efficient** evaporative cooling.
7. Russia's **ongoing** effort to raise its investments in high performance computers to fuel the growth of its economy

through energy efficiency and **sustainable** technology is **noteworthy**.
8. Virtualization can assist in **distributing** work so that servers are either busy or put in a low-power sleep state.
9. This required major changes to the **underlying** operating system architecture and a new hardware driver model.
10. Another report from Gartner recommends looking for product longevity, including **upgradability** and **modularity**.
11. Parts from **outdated** systems may be salvaged and **recycled** through certain retail outlets and municipal or private recycling centers.
12. Hewlett-Packard recently **unveiled** what it calls "the greenest computer ever".
13. The computer is easy to **disassemble** and meets the European Union's RoHS standards for **the restriction** of the use of certain hazardous substances in electrical and electronic equipment.
14. People in the developing world often live in **recourse-impoverished** world.

3. Form nouns and other possible derivatives from the following verbs:

To sustain; store; reduce; maximize; measure; harm; provide; emit; consume; reduce; supply; solve; recycle; employ; associate; prohibit; resemble; evaporate; legislate; facilitate.

4. Form adjectives from the following words:

Line; hazard; waste; globe; efficiency; holism; fancy; ecology; longevity; harm; substance; environment.

5. Use the following compound words in your own phrases or sentences:

Footprint; workstation; workshop; desktop; software; hardware; drawback; teleconference; telepresence; greenhouse; infrastructure; brainstorm; self-style; trade-off.

6. Give English equivalents to the following words and phrases:

Устойчивые вычисления; электрический ток; эффективные устройства; инновации; нововведение; стратегическое развитие; опасные материалы; вторичная переработка; биоразлагаемые материалы; мозговой штурм; сократить расходы и увеличить доходы; войти в законодательство; иметь воздействие на...; компромиссные решения; модернизация; компьютерная техника; методика; центры сбора и обработки данных; рабочие места.

7. Answer the questions:

1. What are the measures limiting the impact of global warming?
2. How can the transfer of green technology enhance the prospects for sustainable development?
3. What impacts do algorithms have on the amount of computer resources?
4. How can virtualization assist in distributing server's work?
5. What is the difference between "thin" and "fat" clients?
6. What is the role of computer virtualization in computer resources usage?
7. What is being done in the Russian Federation for "green" computing and improving the environment?
8. Do you agree with the opinions of the "green" expert Andy Hopper about the future of the planet?

8. Translate from Russian into English:

1. Сотни миллионов лет биосфера поддерживала оптимальное соотношение важных элементов для жизни планеты.
2. Нескольких десятков лет 20 и 21 столетий оказалось достаточно, чтобы нарушить это равновесие.
3. Внедрение ряда инициатив в области экологичных вычислительных систем в центрах сбора и обработки данных, в сети и на рабочих местах должно уменьшить

вредное воздействие компьютеризации на окружающую среду.

4. В 2010 году Американский совет по энергетическим инновациям, включающий Билла Гейтса и исполнительного директора Дженирал Электрик Джефа Иммельта, опубликовал отчет «Бизнес-план энергетического будущего Америки». Группа предложила руководству США утроить инвестиции в исследование будущего энергетики.

5.Какое отношение это имеет к «экологичным ИТ»? Уже сейчас мы используем новые способы расходования энергии, которые невозможно было предсказать 10 лет тому назад, и можно с уверенностью сказать, что еще через 10 лет ситуация снова поменяется.

6. Технологии виртуализации серверов помогают ИТ – архитекторам обеспечить более высокую производительность в расчете на ватт потребляемой энергии в сравнении с невиртуализованными или автономными серверами.

7."Попытка назвать четкое определение "зеленого" ЦОДа(Data Center) будет напоминать упражнение по стрельбе по движущейся мишени", – уверен менеджер по маркетингу ИТ-решений BCC Company Сергей Березин. По его словам, с каждым годом, если не сказать кварталом, в понятие "зеленый" ЦОД вносятся элементы, дающие новые ориентиры в снижении энергопотребления и отрицательной нагрузки на экологию. Например, на Западе недавно появился и активно продвигается пока еще неофициальный стандарт Green 2.0 (или "Экологичность 2.0"), предполагающий измерение энергопотребления ЦОДа на детальном уровне – вплоть до стоек и отдельных серверов, постоянного мониторинга всей энергонагрузки центра и управления ею. Стандарт Green 2.0 разработан специализированной отраслевой группой Data Center Pulse (DCP), объединяющей более 1,3 тыс. глобальных операторов центров обработки данных в 55 странах. Дин

Нельсон (Dean Nelson), основатель и руководитель DCP (Direct Connect Portal), убежден, что необходимо пересмотреть базовые принципы проектирования устройств.

9. Summarize the text and express your own opinion. Here are some possible statements to support:

1. The transfer of green technology can enhance the prospects for sustainable development.
2. Why has the problem of environmental protection become an object of growing world concern?
3. Man and the Biosphere.
4. The changes that green computing is undergoing now.

10. Develop the following idea in writing an essay - "Why green computing efforts are impossible without broad international cooperation" (120-150 words).

Cloud Computing

Words and Phrases:

A challenge	– задача, вызов
A shared pool	- общий пул
Configurable	- конфигурируемый
Provisioned	- предусмотренный
A buzz phrase	- привычная фраза
The late	– покойный, умерший
Public utility	- коммунальная служба
High bandwidth networking	- высокая пропускная способность сети
Advent	- появление
Enabling technology	– высокоэффективная технология
Rigid	- жесткий
Agility	- ловкость
Middleware	- промежуточный
Generic word processing	- общая обработка текстов
Customized programs	– автоматизированные программы
Proponents	- сторонники
A metered fee	- установленная твердая оплата
Option	- вариант
Grid Computing System	- сетевая система компании
Proprietary information	– конфиденциальная информация
To safeguard	- защитить
Jittery	- осторожный
To duplicate	- дублировать
To loom	- маячить
To get hooked up	– подключаться

Even though the technology faces several significant challenges, many vendors and industry observers predict a

bright future for cloud computing.
Cloud computing is a phrase used to describe the computing concepts that involve a large number of computers connected through the Internet. It is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility over the Internet.
In common usage, the term "cloud" is a metaphor. The origin of the term is unclear. The expression "cloud" is used in science to describe a large agglomeration of objects that visually appear from a distance as a cloud. It also describes any set of things whose details are not inspected further in a given context. More commonly the phrase refers to network-based services provided by real server hardware. It's a model for enabling on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, and applications) that can be rapidly provisioned and released. Typically, the seller has actual energy-consuming servers which host products and services from a remote location, so end-users can simply log on to the network without installing anything of their own.
Although "cloud computing" is the current buzz phrase, the concept has been around for half a century. The underlying concept of cloud computing dates back to the 1950s, when large-scale mainframe computers became available in academia and corporations, accessible via clients/ terminal computers. In 1961, the late John McCarthy, an artificial intelligence pioneer, proposed a different term for what is essentially the same thing: "utility computing". He said: "Computing may someday be organized as a public utility, just as the telephone system is a public utility".
But at that time, and for several decades afterwards, computer hardware and software weren't up to the task. Only in the past few years, with the advent of high-bandwidth networking, Web-based applications, and powerful and cheap server technology, has McCarthy's vision finally been realized. To make more efficient use of costly mainframes, a practice

evolved that allowed users to share both the physical access to the computer from multiple terminals as well as to share the CPU time.

Characteristics

Cloud computing exhibits the following key characteristics:

- The systems architecture involved in the delivery of cloud computing, typically includes multiple cloud components communicating with each other over a loose coupling mechanism such as a messaging queue.
- Agility improves with the users' ability to reprovision technological infrastructure resources.
- Application programming interface (API) accessibility to software that enables machines to interact with cloud software in the same way the user interface facilitates interaction between humans and computer.
- Device and location independence enable users to access systems using a Web browser regardless of their location or what they are using (e.g. PC, mobile phone). As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet - the users can connect from anywhere.
- Cost is claimed to be reduced and in a public cloud delivery model capital expenditure is converted to operational expenditure.
- Multi-tenancy enables sharing of resources and costs across a large pool of users.
- Scalability and Elasticity via dynamic provisioning of resources on a fine-grained, self-service basis near real-time.
- Performance is monitored, and consistent and loosely coupled architectures are constructed using Web services as the system interface.

The main enabling technology for cloud computing is virtualization. Virtualization lets a single PC or server simultaneously run multiple operating systems or multiple sessions of a single OS. Virtualization generalizes the physical infrastructure, which is the most rigid component, and makes it available as a soft component that is easy to use and manage. By doing so, virtualization provides the agility required to speed up IT operations, and reduces cost by increasing infrastructure utilization. On the other hand, autonomic computing automates the process through which the user can make use of provision resources on-demand. By minimizing user involvement, automation speeds up the process and reduces the possibility of human errors.

The major models of cloud computing services are known as *Software as a Service, Platform as a Service, and Infrastructure as a Service.* These cloud services may be offered in a Public, Private or Hybrid network.

Cloud Computing Applications

The applications of cloud computing are practically limitless. With the right middleware, a cloud computing system can execute all the programs which a normal computer can run. Potentially, everything from generic word processing software to customized computer programs designed for a specific company can work on a cloud computing system.

Why would anyone want to rely on another computer system to run programs and store data? Here are just a few reasons:

- Clients would be able to access their applications and data from anywhere at any time. They could access the cloud computing system using any computer linked to the Internet. Data wouldn't be confined to a hard drive on one user's computer or even a corporation's internal network.
- It could bring hardware costs down. Working via large platforms owned by providers and shared by numerous users makes cloud computing less expensive, according to proponents. Cloud computing systems would reduce the need for advanced hardware on the client side. The client wouldn't need to buy the fastest computer with the most memory, because the cloud system would take care of those needs for him.
- The terminal could include a monitor, input devices

like a keyboard and a mouse and just enough processing power to run the middleware necessary to connect to the cloud system. A user wouldn't need a large hard drive because he'd store all information on a remote computer.

- Corporations that rely on computers have to be sure they have the right software in place to achieve goals. Cloud computing systems give these organizations wide access to computer applications. The companies don't have to buy a set of software or software licenses for every employee. Instead, the company could pay a metered fee to a cloud computing company.
- Servers and digital storage devices take up space. Some companies rent physical space to store servers and databases because they don't have it available on site. Cloud computing gives these companies the option of storing data on someone else's hardware, removing the need for physical space on the front end.
- If the cloud computing system's back end is a grid computing system, then the client could take advantage of the entire network's processing power. Often, scientists and researchers work with calculations so complex that it might take “years” for individual computers to complete them. On a grid computing system, the client could send the calculation to the cloud for processing. The cloud system would tap into the processing power of all available computers on the back end, significantly speeding up the calculation.
- Cloud engineering is the application of engineering disciplines to cloud computing.It brings a systematic approach to the high level concerns of commercialization, standardization, and governance in conceiving, developing, operating and maintaining cloud computing systems. It is a multidisciplinary method encompassing contributions from diverse areas such as systems, software, Web, performance, information, security, platform, risk, and quality

engineering.

Google, IBM, Microsoft, Oracle, Apple and Rack space corporations are among the most well- known cloud vendors. They offer varying application programming interfaces and abilities generally using SOAP, the Web Services Description Language (WSDL), and other nonproprietary Web service protocols.

Deployment models

Public cloud describes cloud computing in the traditional mainstream sense, whereby resources are dynamically provisioned to the general public on a fine-grained, self-service basis over the Internet, via Web applications/Web services.

Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third party and hosted internally or externally.

Hybrid cloud is a composition of two or more clouds that remain unique entities but are bound together.

Private cloud is an infrastructure operated solely for a single organization whether managed internally or by a third-party and hosted internally or externally.

As cloud computing is achieving increased popularity, more and more companies are starting to recognize and realize the benefits and advantages of cloud computing. That's why, according to analysts at the technology-research firm Gartner, next year 20 percent of all businesses will no longer own their own servers. That percentage is likely to grow in the coming years. While the benefits of cloud computing seem convincing, there are still potential problems and concerns.

First, as with any emerging approach, there are some fears and uncertainties about the technology's maturity. The transformation of the IT landscape brings with it some new problems stemming from the very nature of outsourcing and from sharing resources with others. These problems include service disruptions and the inability of cloud providers to

accommodate customized networks.
Second, the major concern of many users is cloud computing data security. In many ways, cloud computing is just another form of outsourcing. Traditional outsourcing arrangements - contract manufacturing come with legal, organizational, and technical controls. Cloud computing hasn't yet developed such protections. By moving its data and computation to the cloud, a company runs the risk that the cloud-service provider, another customer, or a hacker might inappropriately gain access to sensitive or proprietary information. Customers just have to trust the cloud-service provider to safeguard their data. But unexpected things can and do happen, even when you're dealing with well-established and presumably well-run companies. Data stored in the cloud might be used anywhere in the world and thus might be subject to state or national data-storage laws related to privacy or record keeping.
So it's no wonder that many IT managers remain jittery. If businesses are going to reap the full benefits of cloud computing, cloud providers will need to do much more to address security concerns.
Data-storage clouds are also vulnerable. One class of attacks exploits a space-saving technique known as data deduplication. Many files that people upload to the cloud end up being duplicates – identical copies of software user manuals, say, or MP3s of Lady Gaga's "Telephone". Deduplication allows a data-storage cloud to keep only one copy of each file. Any time a customer attempts to upload a file, the contents of the file are first compared with other stored files. The new file is uploaded only if it doesn't already exist in the cloud; otherwise the customer's account is linked to the stored file.
Is there a thing as a totally secure cloud? No. Even though the encryption and security power increases at an exponential rate, the threat of hackers still looms in many companies' minds.
Cloud computing is relatively new, particularly for large companies, it promises to change and develop quickly.

Experts say that within four-five years, security systems for cloud computing will be perfected and become stronger. Solutions to various cloud security issues vary through using of multiple cloud providers, standardization of APIs, public key infrastructure (PKI), virtual machine and legal support.
Many universities, vendors and government organizations are investing in research around the topic of cloud computing:
In April 2009, the St Andrews Cloud Computing Co-laboratory was launched, focusing on research in the important new area of cloud computing. Unique in the UK, StACC aims to become an international center of excellence for research in cloud computing and will provide information to businesses interested in using cloud-based services.
In June 2011, the Telecommunications Industry association developed a Cloud Computing White Paper, to analyze the integration challenges and opportunities between cloud services and traditional U.S. telecommunications standards.
In contracting with the main providers there are growing legal issues with cloud contract. There is one such effort that demonstrates a secure cloud infrastructure. With funding from the European Union TClouds (Trustworthy Clouds) project was launched, which includes IBM Research-Zurich, the security company Sirrix, as well as a number of universities and other companies. HP Labs, Intel, and Yahoo have launched the distributed Cloud Research Test Bed - with facilities in Asia, Europe, and north America - to develop innovations such as cloud-computing chips.
TClouds project is building an interconnected global “Cloud of clouds” framework to back up data and applications in case one cloud provider suffers a failure or intrusion. Recently TClouds researchers at the University of Lisbon and at IBM Research-Zurich demonstrated one such “cloud of clouds” architecture. It used a data-replication protocol to store data among four commercial storage clouds – Amazon S3, Rack space Files, Windows Azure Blob Service, and Nirvanix CDN – in such a way that the data were kept confidential and also stored efficiently.

In the future, individual clouds will most likely give way to federations of clouds. That is, businesses will use multiple cloud providers for storage, backup, archiving, computing, and so on, and those separate clouds will link their services. So even if one provider suffers an out-age, customers will still enjoy continued service.
Ultimately, the cloud computing can be made at least as secure as any company's own IT system. "It will become the essential foundation for a greatly expanded IT industry by lowering the economic and technical barriers for millions of developers to bring new offerings to market, and for billions more customers to adopt those offerings", said IDC's Gens. Once that happens, reaching out to a cloud provider for computing needs will be as commonplace as getting hooked up to the gas or electric company.

Notes:

Gartner – research and consulting company specializing in IT markets

Lady Gaga's "Telephone" – a news video featured on YouthTube

MP3 – an encoding format for digital audio designed by the Moving Picture Experts Group.

Front end...back end - In computer science, the **front end** is responsible for collecting input in various forms from the user and processing it to conform to a specification the **back end** can use. The front end is an interface between the user and the back end.

Outsourcing - an effective cost-saving strategy when used properly

Deduplication - the term refers generally to elimination of duplicate or redundant information

A buzz phrase – a phrase connected with a specialized field or group that usually sounds technical

Middleware - the leading business innovation platform for the enterprise and the cloud

Grid computing — a form of distributed and parallel

computing, whereby a 'super and virtual computer' is composed of a cluster of networked, loosely coupled computers acting in concert to perform very large tasks
A mainframe computer — a powerful computer used mainly by large organizations for critical applications, typically bulk data processing
A backup - the copying and archiving of computer data so it may be used to restore the original.
IDC – Information Data Corporation
Gens Frank – IDC researcher in broad industry trends
SOAP – Simple Object Access Protocol

Exercises:

1. Give Russian equivalents to the following words and phrases and explain them in your own words:

To be up to the task; to become available, accessible; on-demand; to bring the costs down; to run the risk; the percentage is likely to grow; to reap the full benefits; to back up data; data-replication; to give way to; hook up; utilization technique; to tap into; a shared pool; to safeguard; processing power

2. Complete the word formation using the prefixes (de, dis, in, il, un, im, ir, up) and suffixes:

Clear; ability; appropriately; available; load; possible; material; rational; regular; directly; experienced; equal; possible; order; kind; to convince; to expect; to apply; to duplicate..

3. Translate the sentences into Russian, paying attention to the compounds:

1. More commonly the phrase refers to **network-based** services provided by real server hardware.
2. **It's** a model for enabling **on-demand** network access to a shared pool of configurable computing resources that can be rapidly provisioned and released.
3. Typically, the seller has actual **energy-consuming** servers

which host products and services from a remote location, so **end-users** can simply log on to the network without installing anything of their own.

4. The underlying concept of cloud computing dates back to the 1950s, when **large-scale mainframe** computers became available in academia and corporations, accessible via clients/ terminal computers.

5. In 1961, the late John McCarthy, **an artificial-intelligence pioneer**, proposed a different term for what is essentially the same thing:" utility computing".

6. Only in the past few years, with the advent of **high-bandwidth** networking, Web-based applications, and powerful and cheap server technology, has McCarthy's vision finally been realized.

7. Virtualization generalizes the physical **infrastructure,** which is the most rigid component, and makes it available as a soft component that is easy to use and manage.

8. If the cloud computing system's **back end** is a grid computing system, then the client could take advantage of the entire network's processing power.

9. Cloud computing gives the option of storing data on someone else's hardware, removing the need for physical space on **the front end**.

10. By moving its data and computation to the cloud, a company runs the risk that **the cloud-service** provider, another customer, or a hacker might inappropriately gain access to sensitive or proprietary information.

11. **Data-storage clouds** are also vulnerable.

12. One class of attacks exploits **a space-saving** technique known as data deduplication. .

13. But unexpected things can and do happen, even when you're dealing with **well-established** and presumably **well-run** companies

14. TClouds' project is building a "Cloud of clouds" **framework** to back up data and applications in case one cloud provider suffers a failure or intrusion **out-age**.

15.Once that happens, reaching out to a cloud provider for computing needs will be as **commonplace** as getting hooked up to the gas or electric company.

4. Give English equivalents to the following words and phases :

Справиться с задачей; ускорить решение; снизить затраты; авторизоваться; датировать; подключиться к; воспользоваться всеми преимуществами; идти на риск; сетевой доступ; использование облачных ресурсов по требованию; затраты; занять достойное место; поставщики; внедрять в промышленность; выгода очевидна; программа для резервного копирования; промежуточное программное обеспечение; чувство осторожности; завоевать популярность; по оценке; востребованные решения.

5. Answer the following questions:

1. What is cloud computing? What is the origin of the term?
2. How long has the concept of "cloud computing" existed?
3. What did John McCarthy compare cloud computing with?
4. What are the conditions or realization of McCarthy's vision?
5. What is the main technology for cloud computing?
6. What are the major models of cloud computing?
7. What applications of cloud computing do you know?
8. What are the main reasons why users need to rely on other computer systems?
9. Which cloud service companies do you know?

6. Translate from Russian into English:

На сегодняшний день облачные вычисления еще не завоевали популярности среди российских заказчиков, что связано с непониманием и нормальным чувством осторожности ко всему новому. Однако, по оценке многих директоров по информационным технологиям, рынок облачных вычислений и соответствующая инфраструктура уже в 2014 году будут достаточно сформированы, чтобы занять достойное место среди IT-технологий. Уже сейчас, несмотря на возникающие трудности, несколько российских поставщиков коммерческих решений уверенно предлагают заказчикам понятную модель востребованных решений на основе облачных вычислений.

В настоящее время среди популярных направлений Cloud Computing, которые можно уверенно внедрить в промышленную эксплуатацию, стоит выделить решения с применением технологий виртуализации. Такие решения удобно внедрять в приватных облачных средах, контролируемых какой-либо организацией. Выгода крупных компаний, которые переведут рабочие места служащих на «тонкие клиенты», очевидна. Такая методика позволит минимизировать расходы на содержание и администрирование компьютерной техники компании, а также сэкономит электроэнергию, так как тонкие клиенты в 10 раз экономичнее ПК в потреблении электричества.

Экономия электроэнергии и расходов на поддержку отдела IT – далеко не все достоинства технологий облачных вычислений. Применяя облачные вычисления на базе виртуализации для разработки и тестирования, разработчики могут в любой момент рассчитывать на получение необходимых серверных мощностей.

7. Develop the following ideas in writing an essay (120-150 words):

1. The history of cloud computing
2. The characteristics of cloud computing
3. Advantages and Problems of Cloud Computing
4. The future of cloud computing

Social Multimedia Computing

Words and phrases:

Prevalence – широкая распространённость
To trigger – инициировать
Collaboration – сотрудничество
Spontaneity – естественность
Security breaches – нарушение правил безопасности
Intrusive – навязчивый, назойливый
Invasion of privacy – вмешательство в личную жизнь
Video surveillance systems – система видеонаблюдения
Law enforcement – правовое принуждение; применение закона
Pervasive data – всюду проникающие, распространяющиеся данные
Ubiquitous - повсеместный
To spawn - размножаться, порождать
Collusion – тайный сговор
Whitewashing - приукрашивать
To alleviate – смягчать, облегчать
A hotspot – точка доступа
Edutainment – обучение с элементами развлечения
Time-critical - срочный
A colluder - участник монопольного сговора
Ancillary – вспомогательный, добавочный

Blogs and social networks are becoming an increasingly important part of media consumption for Internet users. With the ubiquitous presence of capture devices such as phones, digital cameras, and camcorders, the Internet has been transformed into a major channel for multimedia content delivery. The next evolution is upon us, as the past decade has witnessed a coming together of social networking sites —Facebook, MySpace, Blogger, LinkedIn — and content-sharing services — YouTube, Flickr, Youku — that have sprung up as platforms to facilitate users' creating and sharing content as well as building large groups of friends.

The hybrid of multimedia and social media, which we call *social multimedia,* supports new types of user interaction. For example, YouTube recently introduced a feature that lets users respond to other users' video contributions, thereby creating asynchronous multimedia conversations. Social multimedia also provides an additional context for understanding multimedia content. For example, aggregating behavioral data (such as click and pause) over all users watching the same video might reveal the video's most interesting scenes or objects. Clearly, social multimedia has great potential to change how we communicate and collaborate.

Computing technology has similarly evolved rapidly over the past decade. Motivated by the growth of social media applications, social computing has emerged as a novel computing paradigm that involves studying and managing social behavior and organizational dynamics to produce intelligent applications. However, the wide prevalence of social multimedia poses a significant challenge for social computing because many new issues involving social activity and interaction around multimedia must be addressed in a media-specific manner.

Nevertheless, multimedia research still remains open, given the challenging nature of this area's research focus. Social multimedia can help improve existing multimedia applications, so we use the term *social multimedia computing* to denote the more focused multidisciplinary research and application field between social sciences and multimedia technology.

Major Application Areas

In a broad sense, we can use social multimedia computing in any application area that uses social multimedia as input, such as online content-sharing sites. It also offers different avenues for the multimedia domain by improving existing multimedia

applications and spawning attractive alternatives.
In the history of social multimedia, YouTube is undoubtedly one of the major milestones, mainly because it created a platform that provides an attractive user experience around sharing video online. YouTube's success triggered other online content-sharing sites such as Flickr, Digg, and Youku, all of which offer users the option to upload, share, and tag images, audios, and videos, and create social networks by designating contacts or friends. A similar service, videoblogging, or vlogging, combines embedded videos or video links with supporting text and images. A typical example is Barack Obama's vlog in the 2008 US presidential election.
As a surrogate to content-based searches currently in their infancy, collaborative recommendation is an important tool for finding multimedia content.
Compared to online video-sharing services, vlogs demonstrate stronger social characteristics, such as social networks. They also provide better social-interaction data to facilitate analyzing temporal interaction dynamics because entities are often archived in reverse chronological order. Online content sharing and vlogging have experienced tremendous growth in the past several years and created a huge marketing opportunity. According to eMarketer, online content-sharing sites will attract 101 million users in the US and earn $4.3 billion in ad revenue by 2011.
Social multimedia computing, together with online communities, could help create more capable computational infrastructures to support interaction, group activity, and collaborative work. Google's Picasa offers one example. Although originally designed as a software application for editing and organizing digital photos, people now use Picasa to collect, share, and tag photos. Another example is in YouTube's video response mechanism, which lets users provide reviews for products or places and exchange opinions about certain topics through a much richer media than simple text. This video-based interaction opens new doors for originality and spontaneity in user interactions.

Ideas and technologies from social multimedia computing have recently found their applications in communication channels such as peer-to-peer networks. A P2P network consists of nodes, or peers, that act as both resource suppliers and consumers of resources; they can share a portion of these resources — such as disk storage and network bandwidth — with other peers. However, the lack of authority or structure poses several challenges for unstructured P2P systems, including free-riding, the existence of firewalls/NATs, security breaches, and malicious behavior, including cheating, whitewashing, and collusion. To alleviate these problems, we can model P2P networks as multimedia social networks and then analyze user behavior and the impact of human dynamics on multimedia communication. Modeling P2P networks as social structures can allow incentive, reputation, or payment mechanisms to reward good peers and punish misbehaviors so that peers are more inclined to cooperate. Such modeling and analysis provides fundamental guidelines to better design multimedia networking systems. A recent survey of Skype, for example, showed that the performance problems resulting from free-riding and NATs could be reduced by applying social networks in P2P systems.

Social multimedia search

Multimedia search provides an important application area for social multimedia computing. The proliferation of user-generated content (UGC) and the associated metadata on social multimedia sites introduces new challenges in search, including vulnerability to spam and noise, and short lifespan. Further, much of the content offers little value to the general public, and access control restricts most UGC messages to only a few recipients. Thus by using social network analysis and socially collected data, social multimedia computing could enable improved content analysis.

As a surrogate to content-based searches currently in their infancy, collaborative recommendation is an important tool for finding multimedia content. For example, developers estimate that 53 percent of online video searchers discovered online video content through friends. So user-behavior models and multimedia social networks could be used to create a recommender system that helps people find images or videos and potential collaborators.

Interactive services and entertainment

Interactive service is one of the most promising application areas of social multimedia computing — one such example is online video advertising. Although Web advertising is interactive by nature, hyperlinked videos and vlogs offer a unique and more complex level of engagement with their precise targeting capability. This new advertising model is less intrusive, displaying advertising information only when the user chooses it by clicking on an object in a video. By learning user preferences through multimedia social network analysis, the hotspots that correspond to brands could be further highlighted to extract more interests from users.

An increasing trend is to harness the wisdom of crowds. This is particularly true in interactive entertainment such as gaming, storytelling, and edutainment. Recently, researchers have explored collective intelligence in the form of online games, called games with a purpose. By playing these games, people contribute to their understanding of entities on the Web and even collectively solve large-scale computational problems such as categorizing online pictures, monitoring distributed security cameras, and improving online video search.

Healthcare

According to recent public health findings, physical health factors such as obesity, emotional health factors such as happiness or depression, and harmful habits such as smoking can significantly affect an individual's social network. Using online social networks for healthcare provides an opportunity to analyze behavioral data and study social structures formed as a result of ties to health behaviors. Both the American Cancer Society and the Centers for Disease Control and Prevention, for example, have experimented with virtual communities such as Second Life to test whether social multimedia can help spread the word about such issues as nutrition awareness, cancer screening, and infectious-disease prevention.

Collaboratively monitoring health status across media with ubiquitous wireless sensors and cameras could also help medical staff craft an effective healthcare application. For example, an ECG sensor carried by an elderly person with physical disabilities might capture any unusual heartbeat rates and send this information through a social network of family members, physicians, friends, and emergency services; the information's context — at home or outdoors, for example — could help physicians make time-critical decisions. However, the usage of such sensor data will also give rise to privacy issues. In practice, it could be less privacy invasive if these sensor data are strictly restricted for use in healthcare applications.

Security applications

We can characterize many security applications as social multimedia computing applications. They've emerged especially rapidly in recent years with the proliferation of video surveillance systems in a wide variety of domains, such as homes, banks, airports, and convenience stores. Various government entities have used social network analysis to analyze terrorist networks, communications, criminal organizations, and resources. However, to date, few works have focused on social network analysis in surveillance video.

In spite of the possible invasion of privacy, mastering the role such networks play in monitoring surveillance video data is of great interest to law enforcement and homeland security. For example, DARPA is soliciting innovative research proposals to develop the Persistent Stare Exploitation and Analysis System for automatically and interactively discovering actionable intelligence through wide-area-threat analysis of complex motion imagery surveillance of urban, suburban, and rural environments.

Although work in social network analysis, multimedia content analysis, and other disciplines can be adapted to social multimedia computing systems, numerous problems in modeling, analyzing, and utilizing multimedia social networks have yet to be solved.

Multimedia social dynamics

Social networks often involve many users of different types — from rational to selfish and malicious — all with different objectives. Thus, modeling and analyzing user behaviors and social dynamics poses a fundamental challenge to help stimulate user cooperation, maximize overall system performance, and minimize the damage caused by malicious users.

Several specific multimedia properties make analyzing multimedia social dynamics different from traditional social network analysis. First, user behaviors are highly dynamic, especially when users watch live streaming video on the same wireless network or share the same limited backbone connection to the Internet.

Second, the modeling and analysis of user behaviors are mostly content-relevant. In colluder social networks, for example, multimedia fingerprinting or other content identification technologies could model user behavior and track people who illegally use copyrighted multimedia.

Third, the potential rewards are time-sensitive. For example, the earlier a colluded copy is released, the more people will be willing to pay for it. Thus, all colluders have an incentive to mount collusion as soon as possible.

Multimedia interaction dynamics

Intuitively, developing new multimedia social interaction tools requires a close integration of sociology, multimedia, and communications technologies. Specifically, the social science studies addressing the dynamics of large-scale social interaction and activity might revitalize research into novel social interaction methods and tools. Twitter, originally conceived as a mobile status update service that provides an easy way to keep in touch with friends, offers one example. Twitter users send and receive short, frequent answers to one question, "What are you doing?"

However, Twitter changed that question to "What's happening?" so that people, organizations, and businesses could leverage the network's open nature to share anything they wanted, including pictures and video. This shift created a new kind of information network in its users' social space. In this sense, social scientists should take a more active role in coping with the challenge of developing new multimedia tools to enable more powerful social interaction.

A greater challenge requires developing user interfaces and interaction paradigms to allow seamless communication and interaction with remote and virtual environments. In practice, this vision is achievable by combining new sensors that cover touch, smell, taste, and motion; immersive output devices such as large displays, and 3D technology.

Social multimedia community analysis

Social multimedia provides several effective ways to harvest the large-scale digital traces of social behaviors, such as online content sharing, vlogging, and video surveillance. With the increasing availability of such pervasive data, key research challenges will involve developing methodologies for large-scale validations of social science theories and for new theories and inferential analysis methods that can analyze this kind of new data.

For example, several studies have focused on social behavior and organization dynamics in online text-blog communities. Without considering the multimedia properties of the community structure, these social network analysis models can be directly used in vlog communities. However, the problem becomes much more complex if we consider the interrelation among the content, social, and temporal dimensions of vlogs. For example, large-scale experiments are needed to verify whether the "six-degrees-of-separation principle" remains valid in vlog communities, given that the change of media forms from text-only to video might speed up information propagation and consequently shorten networks. This study could shed new insights into real-world applications such as online advertising and viral marketing.

Privacy protection

Most social multimedia data are proprietary, such as user profile data — name, place, date of birth, and e-mail address — or ancillary data such as the IP address or time of connection. Properly managing privacy issues is essential both to facilitate research and safeguard consumer privacy. Nevertheless, the privacy issues surrounding social multimedia data are more complex. Generally speaking, users should have the right to control their personal data, which implies getting access to the data, modifying it, asking for corrections, or asking for deletion. However, this right isn't easily guaranteed in the context of social multimedia. For example, users are usually eager to share pictures in online communities, but these images can easily be used for secondary purposes such as face recognition and image retrieval, especially when tagged with metadata such as name, e-mail address, and physical address of the person pictured. Because a single dramatic incident involving a breach of privacy could produce rules and statutes that stifle the nascent field of social multimedia computing, a systematic study of privacy issues and their corresponding technological, procedural, and rule-related developments must be undertaken to reduce security risks and preserve research potential. The explosive growth of social multimedia on the Internet is revolutionizing the way content distribution and social interaction work while presenting an evolving multidisciplinary research and application field. At present, this research addresses the descriptive analysis level, but the potential for developing social multimedia computing theories and methods remains promising.

Notes:

A milestone - a stone set up beside a road to mark the distance in miles to a particular place; figuratively - an action or event marking a significant change or stage in development
A vlog – a video blog or video log (pronounced 'vlog' or 'v-log'), a form of blog for which the medium is video
A P2P network – a peer-to-peer; denoting a network or data communications in which no dedicated server is involved

NAT - Network address translation
Free-riding - enjoying a service without paying for it
ECG (or EKG from Greek: *kardia*, meaning heart) - Electrocardiography

Exercises:

1. Give Russian equivalents to the following words and phrases and explain them in your own words:

the ubiquitous presence of smth; to pose a challenge for smth; video surveillance; capture social activity and interaction; to harvest large-scale digital traces; a milestone; to harness the wisdom of crowds; a core role; live streaming video; time-sensitive

2. Complete the word formation using prefixes and suffixes:

Interact; consumption; respond; behavioral; organize; prevail; cooperation; intrude; benefit

3. Translate the sentences into Russian paying attention to the compounds:

1. YouTube's success triggered other online **content-sharing** sites such as Flickr, Digg, and Youku.
2. As a surrogate to **content-based** searches currently in their infancy, collaborative recommendation is an important tool for finding multimedia content.
3. They also provide better **social-interaction** data to facilitate analyzing temporal interaction dynamics because entities are often archived in reverse chronological order.
4. Ideas and technologies from social multimedia computing have recently found their applications in communication channels such as **peer-to-peer** networks.
5. The proliferation of **user-generated** content (UGC) and the associated **metadata** on social multimedia sites introduces new challenges in search, including vulnerability to spam and noise, and short **lifespan**.
6. DARPA is soliciting innovative research proposals to develop the Persistent Stare Exploitation and Analysis System for

automatically and interactively discovering actionable intelligence through **wide-area-threat** analysis of complex motion imagery surveillance of urban, suburban, and rural environments.

7. Several studies have focused on social behavior and organization dynamics in online **text-blog** communities.

8. **Large-scale** experiments are needed to verify whether the "**six-degrees-of-separation** principle" remains valid in vlog communities, given that the change of media forms from **text-only** to video might speed up information propagation and consequently shorten networks.

9. This study could shed new insights into **real-world** applications such as online advertising and viral marketing.

4. Give English equivalents to the following words and phrases:

облегчать; содействовать; принимая во внимание; с учетом; вызвать ответную реакцию; сделать следующий шаг; инициировать; дать начало чему-либо; быть склонным делать что-то; деятельность правоохранительных органов; догадаться о; сделать предположение; препятствовать чему-либо; в последующие годы

5. Answer the following questions:

1. What is social media computing?
2. What approach reduces name ambiguity?
3. What is social-empowered multimedia computing?
4. What is collaborative tagging?
5. What are the major application areas of social multimedia computing?
6. What is vlogging?
7. What is a P2P network? What are its challenges?
8. How can we solve the problems of P2P networks?
9. What is free-riding?
10. What does UGC stand for?
11. What are the three different networks that make multimedia

social networks?
12. What are the key challenges of multimedia computing systems?
13. How can we understand contextualized media on three levels of meaning?
14. How do social activities affect multimedia computing?

6. Fill in the blanks with the words and phrases from the article:

1. The 1980s ... an unprecedented increase in the scope of the electronic media.
2. Social multimedia has great ... to change how we communicate and collaborate.
3. The issues raised by social computing are often beyond the general field's .... .
4. Online content sharing and vlogging create a huge marketing ... .
5. The usage of such sensor data will also give ... to privacy issues.
6. A social data network can be ... from online activities such as tagging and collaborative recommendation.
7. The problems can be ... down to three multimedia data-mining tasks.
8. The study could ... new insights into real-world applications such as online advertising and viral marketing.

7. Translate from Russian into English:

«Социальный мультимедийный компьютинг» (Social Multimedia Computing) – новая область междисциплинарных исследований, в которой наводятся мосты между общественными науками и технологией мультимедиа.
Блоги и социальные сети становятся все более важной частью медийного контента, используемого посетителями Internet. При повсеместном наличии мобильных телефонов, цифровых фото- и видеокамер Internet преобразуется в основной канал доставки пользователям

мультимедийного контента. Теперь наблюдается следующий виток эволюции, поскольку за прошедшее десятилетие появились сайты, поддерживающие социальные сети (Facebook, MySpace, Blogger, LinkedIn), и службы совместного использования контента (YouTube, Flickr, Youku), которые становятся платформами, облегчающими производство и совместное использование пользовательского контента, а также создание крупных групп единомышленников.

Гибрид технологий мультимедиа и социальных сетей, который авторы называют социальным мультимедиа, поддерживает новые типы взаимодействий пользователей. Например, в YouTube недавно появилось средство, которое позволяет пользователям откликаться на видеоролики, выложенные другими пользователями, что приводит к появлению асинхронных мультимедийных диалогов. Социальное мультимедиа также обеспечивает дополнительный контекст, облегчающий понимание мультимедийного контента. Например, агрегация данных о поведении всех пользователей, смотрящих один и тот же видеоролик (например, данных о нажатии кнопки «пауза»), может помочь выявить наиболее интересные сцены и объекты этого ролика. Очевидно, что у социального мультимедиа имеется громадный потенциал для изменения способов коммуникации и сотрудничества людей.

В последние годы быстро эволюционировала и компьютерная технология. Под влиянием роста числа приложений социальных сетей возник *социальный компьютинг* – новая парадигма компьютинга, предполагающая исследование общественного поведения и организационной динамики, а также управление ими для создания интеллектуальных приложений. Однако широкое распространение социального мультимедиа ставит перед социальным компьютингом новые серьезные проблемы, связанные с общественной активностью и взаимодействием в контексте

мультимедиа.
Имеется много нерешенных проблем и в области собственно мультимедиа. Социальное мультимедиа может помочь усовершенствовать существующие мультимедийные приложения, и термин *социальный мультимедийный компьютинг* характеризует междисциплинарную область исследований и разработки приложений, опирающихся на достижения в области общественных наук и технологии мультимедиа.

8. Develop the following ideas in writing an essay (120-150 words):

1. The challenges facing multimedia computing and ways to solve them.
2. The future of multimedia computing: your prognosis.
3. Piracy and collusion dynamics on multimedia social networks: dangers and solutions.
4. The privacy protection issues in social multimedia: ways to guarantee it.

Appendix
Some tips on the analysis and translation of written material

When you translate the text from English into Russian as close as possible to the original you receive a **literal translation**. However, it is desirable that a translation of the original scientific text be not literal, but **adequate**.
For an adequate translation of scientific texts, it is important to take into account:

- the special focus of the text
- the context
- the structural features of the original language
- the translation of individual words, collocations and terms.

In an adequate translation from English into Russian, it is important to find the only possible lexical compliance and the grammatical forms in the Russian language that most closely reflect the grammatical structures of the English sentences.

How to write a summary

A summary is a brief account giving the main points of a matter. Its ultimate aim in written practice is to present ideas of the written materials clearly and concisely expressed.
The summaries or abstracts can be different. They can refer to one big scientific work or to a round-up of several works devoted to the same theme. However, the basic idea of the proposed method of writing a summary or an essay in English is not to give a word for word translation into English, but to try to present it clearly, and creatively. The principle of understanding and comparing the semantics and the grammatical structures of the original Russian phrases and relevant words and expressions in English is at the heart of writing your own research papers in English.
Stage 1.

Before you write a summary, you need to read the whole text and understand its contents (**scheming reading**). Next, you need to write down the main ideas of the text in a logical order and then divide the text into the introduction, the main or principal part, and the conclusion.

Stage 2.

At the next step you need to go back to reading of the text with the purpose of analyzing its lexical and grammatical structures and overcoming the main language difficulties (**close reading**).

You need to find the main idea in each textual unit (a paragraph) of the paper or the book and define the topic sentences in it.

You should give each paragraph a suitable title and pass to a logical plan of the items.

Stage 3. Finally, you should combine the kernel sentences into a coherent summary using connective words. Reread your summary and make sure that it has the logical order of the material presentation. Your concluding paragraph should be a statement of your own ideas.

Do not forget to mention the title of the book or the article and the author's full name.

How to write a composition or an essay

Key words:

Научная статья - a scientific article, a paper
Реферат - a summary, an abstract, a synopsis
Тезисы доклада - abstracts of communication, theses
Рецензия - a review

It is commonplace that no distinction is made between a composition and an essay writing, and students are often free to interpret the subjects set in any way they like. However, these two forms of the written work have some differences.

In a composition, students may set out the facts as they are.

In an essay, the main task is not only to render the facts but also to give an individual interpretation of them.

Let us imagine that the subject of the essay is *The Historical Development of Computers*. If you write **a composition** you may be expected to deal with the history and evolution of computers, collecting different materials on this problem. But in **an essay**, besides presenting the material of your choice, you can express your own ideas, opinions, and sometimes feelings and emotions.

For this reason an essay writing is a more difficult form of exercise, though more satisfying, as it gives a student more opportunity for self-expression.

According to the subject matter, essays may be divided into four main types: **narrative, descriptive, reflective, and argumentative or discursive.**

Compared with the narrative and descriptive essays, reflective and argumentative essays are more difficult to write, not only because it is more difficult to arrange the ideas logically, but also because one devotes more thought and time to the collection of ideas relevant to the subject.

To write a summary, an essay, or a composition in English students may require **standard phrases**, **verbal stereotypes or clichйs** that facilitate communication and save time and efforts of the author. Combining them correctly, students can express necessary scientific or mathematical ideas properly. There are a few of them:

1. General characteristics of the article. E.g.:

The paper (article) under discussion...

The objective of the article is to describe (explain, examine, survey)...

The purpose of the research is to prove (find, develop...)...

The article gives a detailed (valuable) analysis of the information on...

The article is of great help to...

The paper is of great interest to...

The paper is devoted to (concerned with)..., etc.

2. The problems posed by the author. E.g.:

The author outlines (points out, reviews, analyses)...

The authors refer to...
The authors give a review of...
The authors come to the conclusion..., etc.

3. The evaluation of the results of research. E.g.:

The obtained results show (lead to, confirm)...
It should be noted ...
The presented results well agree with...
It is likely (unlikely, certain, sure)..., etc.

While writing a paper in English students should pay attention to:

Typical set phrases consisting of verbs + nouns. E.g.:

To perform (undertake) a study of
To make (calculation, estimation, evaluation) of...
To carry out an investigation...
To perform the analysis of (on)...
To give a description of...

The frequent use of passive constructions. E.g.:

The paper is concerned with...
It is known that...
It is stressed that...
The research is carried out...
It was shown that ...
It was concluded that ...
It was inferred from ...
The new theory (technique) is developed (worked out, proposed, suggested, advanced) to...
The new method (technique) is discussed (tested, described) ....
This method (theory) is based on ...
This method is now generally accepted ...
Special attention is paid (given) to ...
The factors are taken ...
The following conclusions are taken into consideration ..., etc.

Combinations: in detail, in range of..., within the range of..., it follows that...

Connective words: where, if, when, whenever, such that, although, unless, provided, therefore, hence, thus, then, furthermore, however, nevertheless, i.e.

Here are some notes about **general principles of the use of the articles** in scientific papers:
1. **Article a** is placed before the term:
- if the term is introduced for the first time
2. **Article the** is used before the term:
- If the term is repeated
- If the term is uniquely determined by the context
- Before the words **the author(s), the paper**, etc.
3 . The **article is not used**
- If the theory or the used reference is provided with a number,
- Before the names of general theories and sciences.

There are a few examples of **the typical errors:**
In expressions “Seitz’s hypothesis”, “Whipple's model” there is **no** article, but in
the Hall Effect, the Boltzmann factor, the Schmidt camera, the Gauze theory **the** is used.

While writing in English pay attention to the difference in the Russian and English punctuation:
1. There is **no** comma before **such that, that** in English subordinate clauses (compare with the Russian language) with the exception when they give addition to the main idea or explain the main sentence.
2. A comma is placed before **and,** showing the end of the enumeration, and sometimes before **as, but, for, or**, if a complex sentence is too long.
3. A comma is put after **therefore, however, by the way, for instance, yes, in fact.**

Some hints on the oral presentation of scientific data

There is a distinct difference between writing a paper and presenting it orally for the audience. It is not a trivial task to give a good presentation. The experts suggest the following plan for this:

- Before getting started greet the audience and call for attention
- State the purpose of the talk, giving a short introduction
- Present the structure of the talk

In the body of the presentation it is advisable to separate the central, relevant issues from merely supportive peripheral information.

Try not to read but to speak using accurate well-phrased descriptions of the scientific information. The manner of the presentation and the contact with the listeners are very important. You should speak distinctly and slowly to the audience in front of you, and not to the laptop or to the screen on the wall.

It is also advisable to use some visual aids (charts, graphs and tables) but not too many.

In conclusion of the presentation it is necessary to thank the listeners and ask for the questions.

There are some advantages of oral presentation, which provide a speaker with an opportunity to receive instant verbal feedback. Such feedback can be useful in providing guidance when preparing a student's presentation as a summary or an essay in a peer-reviewed journal.

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