Санкт-Петербургский Государственный Политехнический Университет

Институт прикладной математики и механики

КАФЕДРА
ТЕЛЕМАТИКА

Семинар по специальности на английском языке

тема Lecture 10

Developing Computing System for New Era

10 November
2022 г.

Что было на прошлой лекции: Semantics of modal formulas

- The semantics of modal formulas are diverse (or we may say – flickering)

  If we have $\Box\phi \rightarrow \phi$

  Then symbol $\Box$ — модальность времени (темпоральная логика), «всегда», то

  $\Box\phi \rightarrow \phi$ — это закон модальной логики.

  Если студенты всегда ходят на лекции, то они ходят на лекции.

  Если $\Box$— деонтическая модальность, «должны», то формула $\Box\phi \rightarrow \phi$ не имеет статуса логического закона.

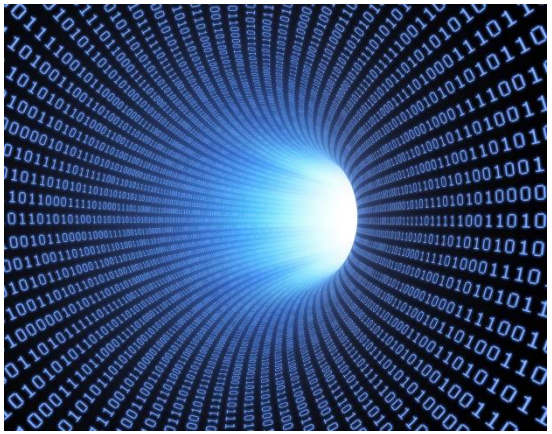
  Если студенты должны ходить на лекции, то они ходят на лекции.

  Это не всегда так !

Key word of new era - Digital “ashes”

Digital model

Digital transformation



Digital distorting mirror

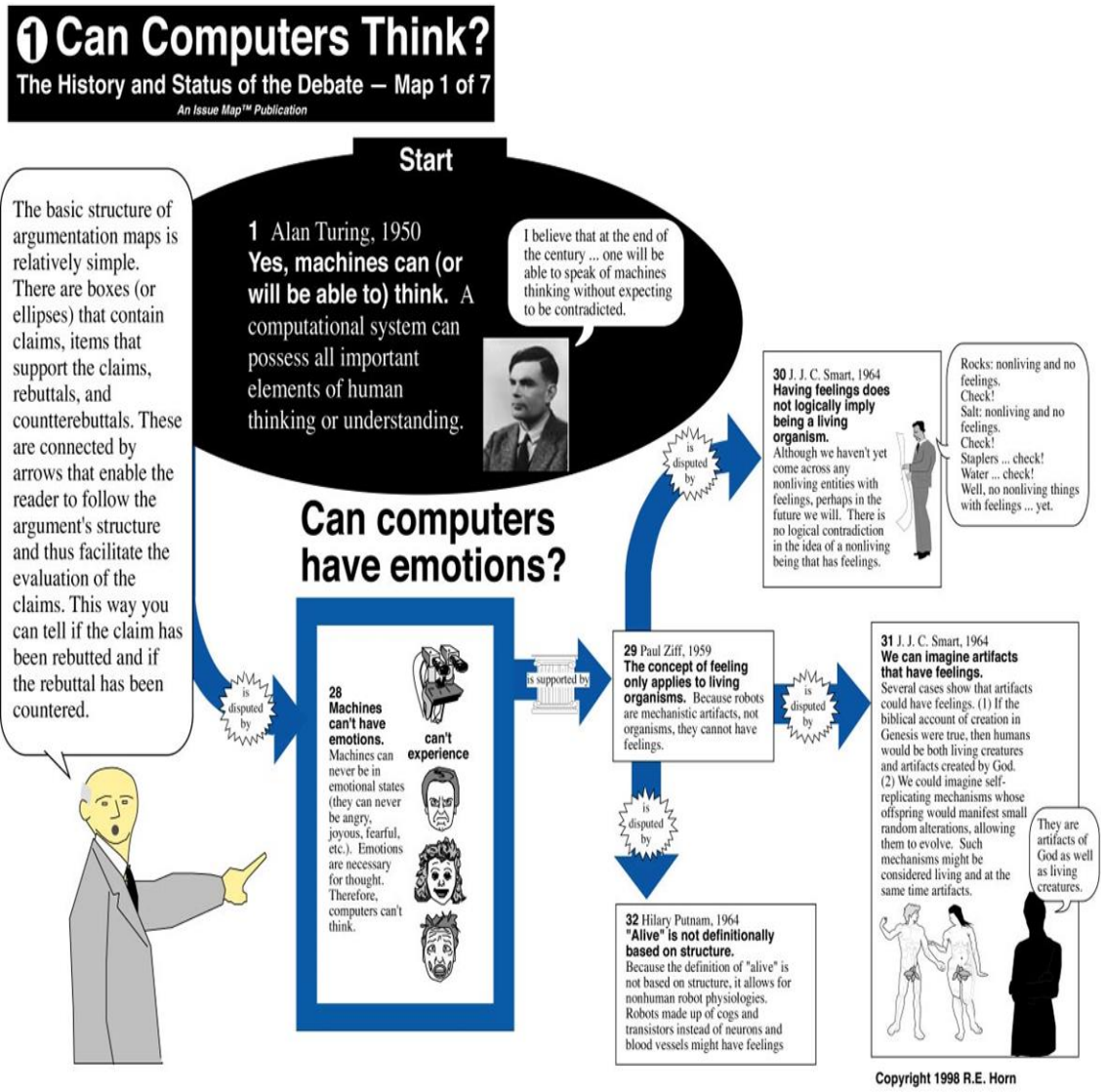
Overview

- The world is continually changing, and one of the fundamental drivers is **digital transformation**

- Digital transformation is about digital economy – new way to do what we already do – but better (more precisely, faster, better). **Digital economic** activity results from billions of everyday online connections among people, businesses, devices, data, and processes.

- So, the backbone of the digital economy is **hyper connectivity & HPC & AI** which means growing interconnectedness of people, organizations, and machines that results from the Internet, mobile technology and the internet of things (IoT).

Noumenon vs Phenomenon



Human knowledge and competencies **becomes of computers resources** ONLY if converts to algorithms or programs.

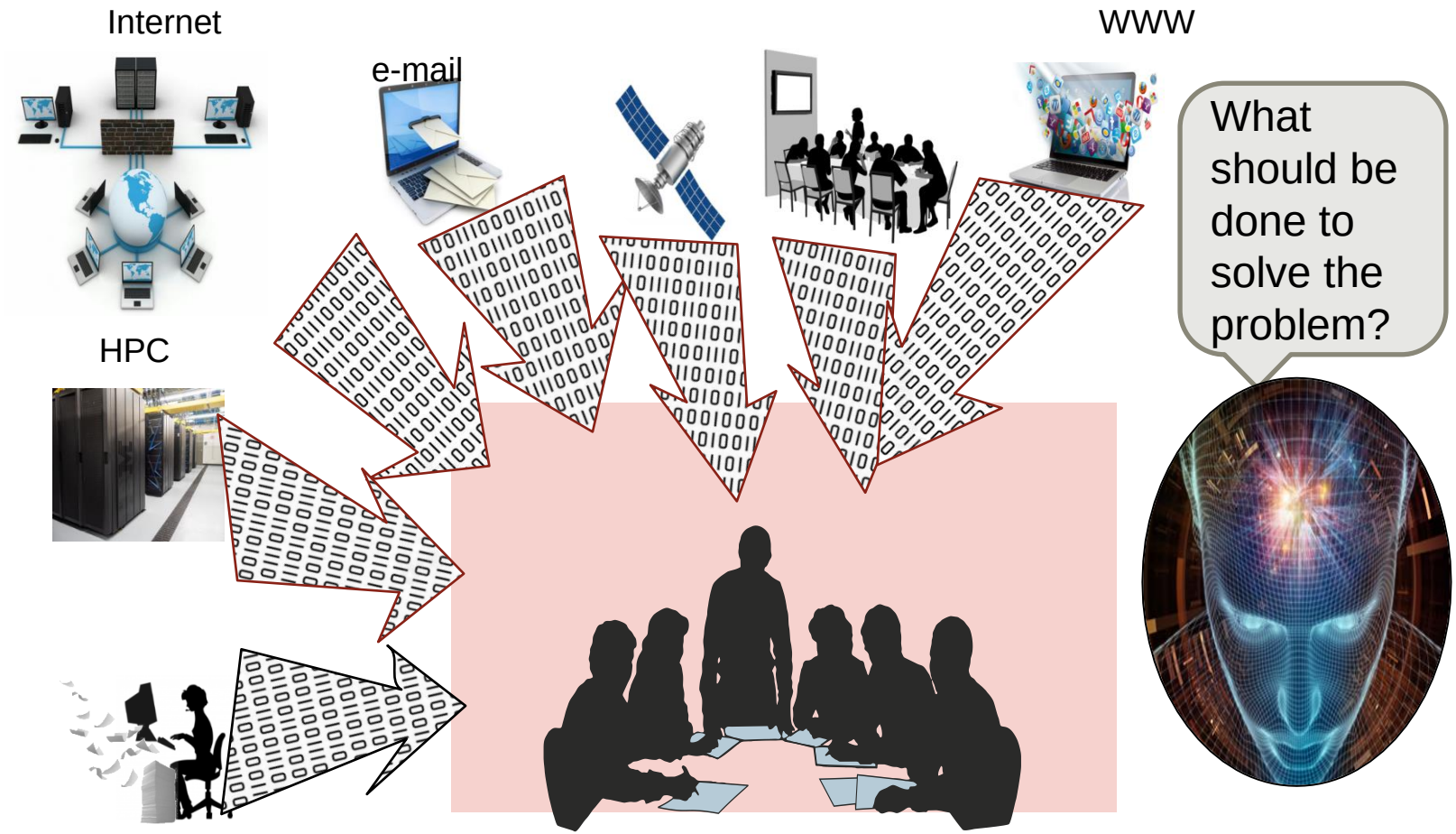
«Eldorado» of the new economy is "digital knowledge" which can be extracts from big data using intellectual technologies .

Intellectualization of computing is a "solution" of problems with a "self-explanation" of its meaning. To do this, we need new technology tools that integrate various computing platforms and principles:

- "Stored" program
- "Neuromorphic" approximation
- regularizing decisions using a measure of similarity

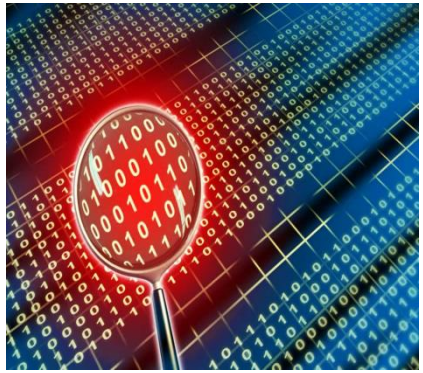
Can we swim through the "Digital Flood"

The subject solving the problem has **little time** to invent an algorithm or create a calculation program (decisions are made on the basis of experience or out of habit)



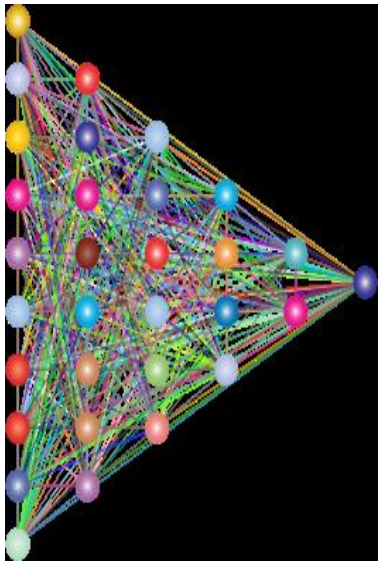
Advance CS paradigm –aFaP calculates "safe" decisions" . New platforms should have: **reconfigurable** heterogeneous processing field, **storage** class memory, **smart** infrastructure and **distributed** architecture

The classic goal of computer science: automation of solving "direct problems": finding numerical solutions of equations using algorithms and programs



The principles of "computer science" - automata can model automata,
algorithms are the "generators" of digital data,
"big data" is the hidden bank of algorithms ...

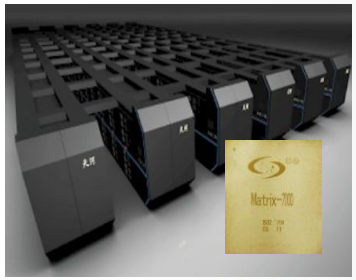
New challenges for computer science: automation of solving “inverse problems”: construction of algorithms, classification and recognition based on available data and a priori knowledge

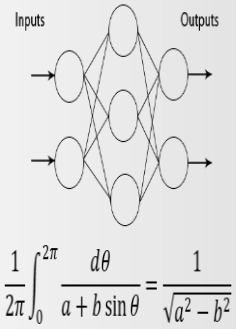


What is being offered: Transition from program control to smart computing

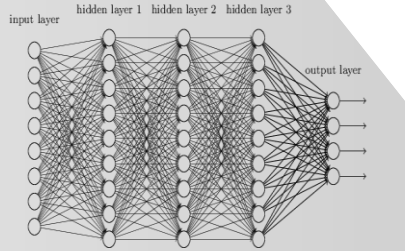
Problem to be solved: data control calculations without an explicit algorithm.
Computer platform is using previous "experience" in solving problems (ML) and similarity metrics of previous data processing

Standard approach:





$$\frac{1}{2\pi}\int_0^{2\pi}\frac{d\theta}{a+b\sin\theta}=\frac{1}{\sqrt{a^2-b^2}}$$



$$\nabla\cdot\nabla\psi=\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}$$
$$=\frac{1}{r^2\sin\theta}\left[\sin\theta\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right)+\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right)+\frac{1}{\sin\theta}\frac{\partial^2\psi}{\partial\varphi^2}\right]$$

Multi-core multi-threaded clusters improved by accelerators and neuromorphic data-driven computational structures

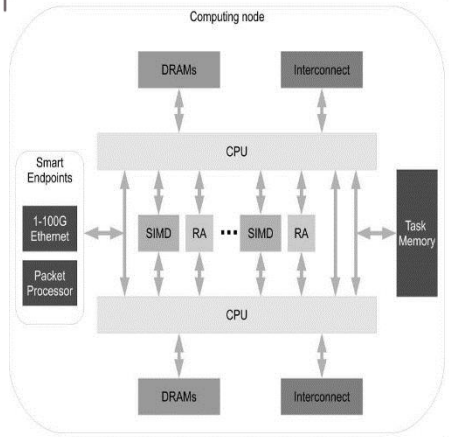
SIMD accelerators

FPGA accelerators

multi-threaded clusters

Smart decision

Adaptation of hardware and software to the data structure and selected algorithms. Key features: 1) processor-memory interfaces - task memory smart fabric (SMF) and 2) runtime system endowed with the functions of "machine learning"

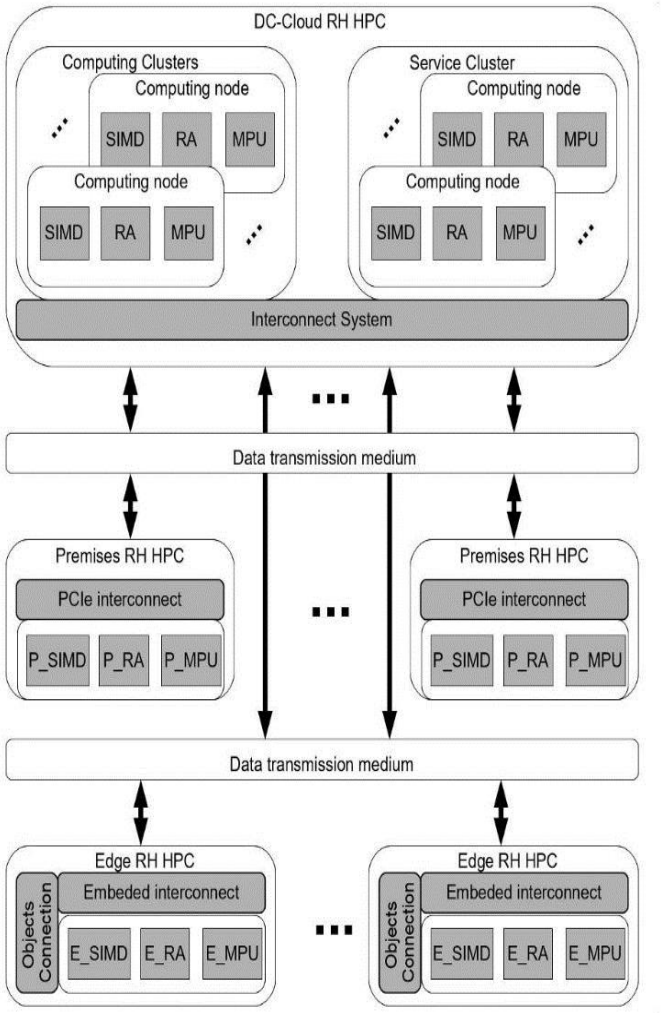


Reconfigurable Heterogeneous Distributed High Performance Computing Architecture

The level of "understanding" and "explanation"

The level of "aggregation" and modeling

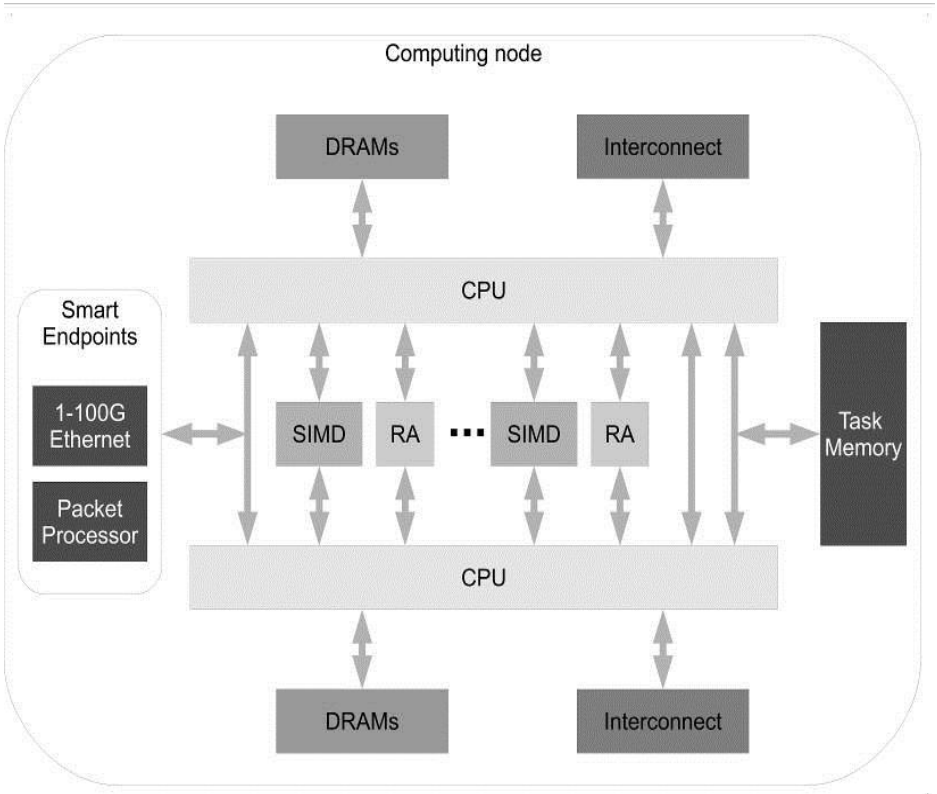
The level of access to the environment of "big data"



The structure of the computing node "level of aggregation"

Heterogeneous computing nodes for service and computing algorithms

- SIMD (Single Instruction Multiple Data accelerator) - a graphics/ tensor accelerator for FP32/FP16/ data
- RA (Reconfigurable FPGA-based Accelerator) - reconfigurable accelerator, the structure of which is adjusted to the "patterns" of the processed data



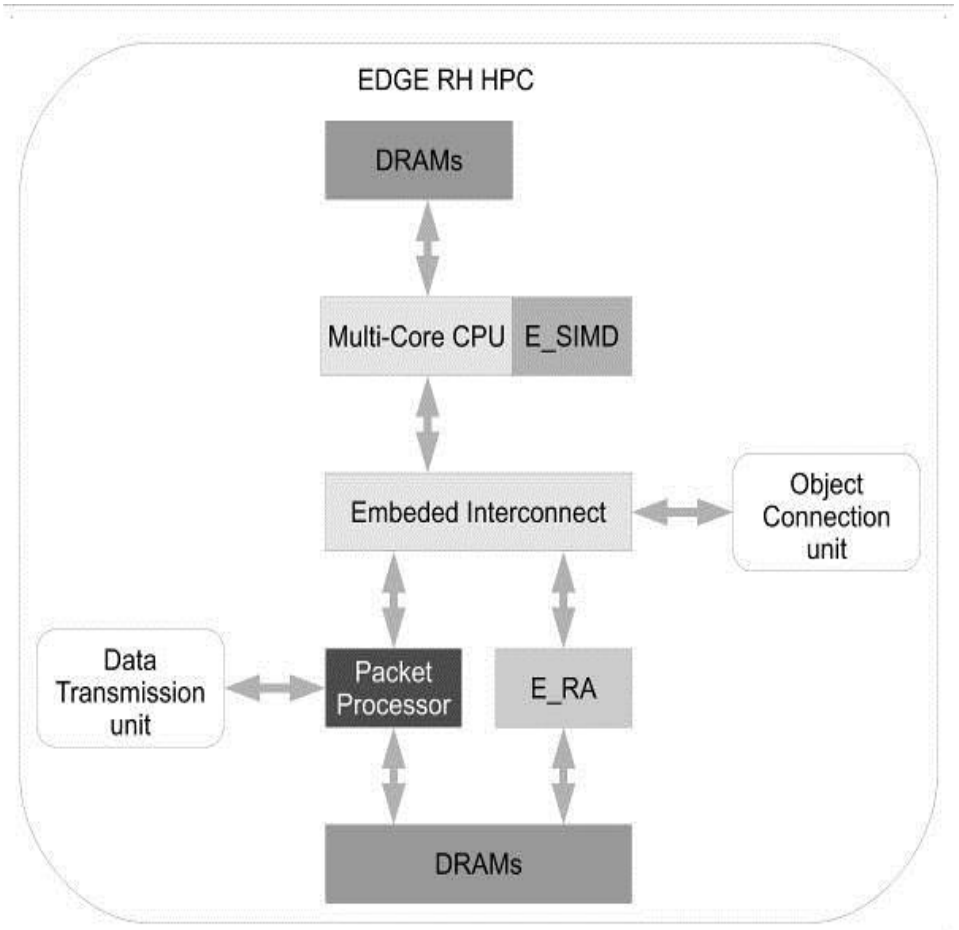
"access" node – connection to the "big data" space

Basic high performance Systems-on-Chip» node with smart interconnection interface improved by packet processor.

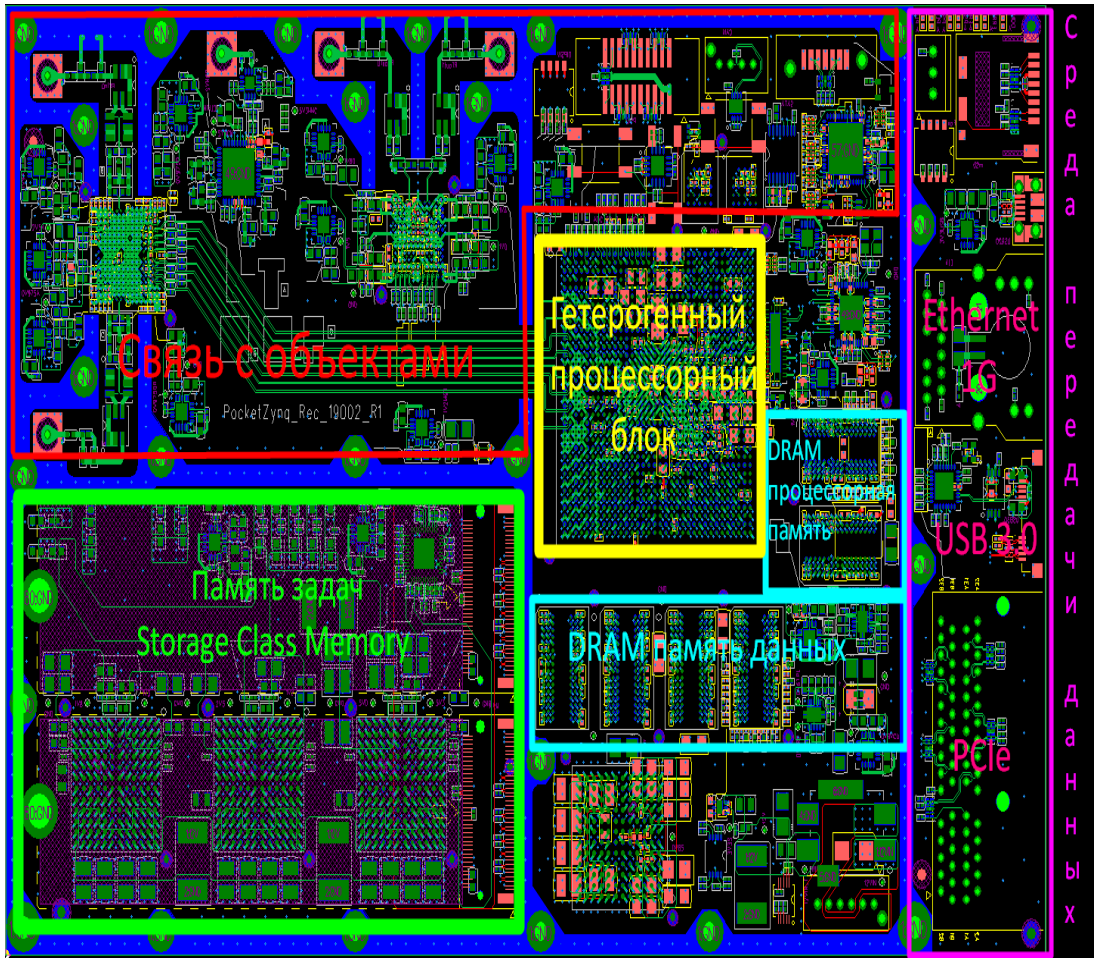
Multi-Core CPU, which is a main processing unit.
E_SIMD accelerator tightly coupled with Multi-Core CPU. It could implemented as a separate Integration Circuit (IC) or as embedded GPGPU unit inside SoC device.

E_RA accelerator, which could be implemented as a separate IC or as embedded unit, deployed on Logic Part of SoC device.

DRAM blocks, which, at the physical level, are DDR4 memory modules. DRAMs are the local memory for Logic Part and Processor Part of SoC device



"access" node - integration Circuit

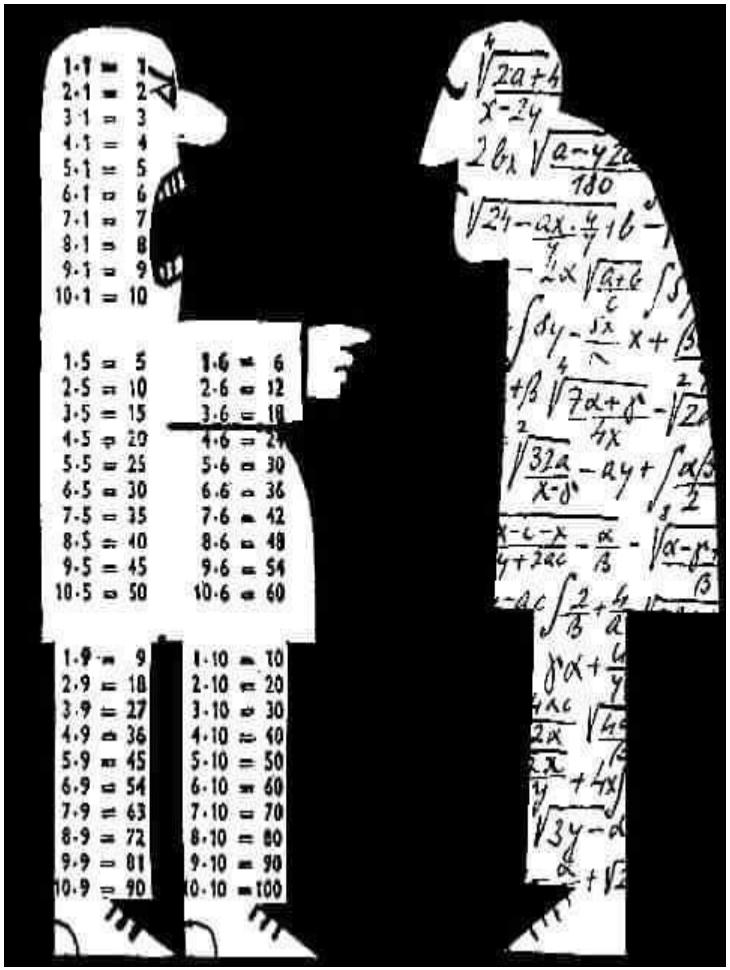


- New generation of Reconfigurable Heterogeneous Distributed High Performance Computing System must have a hardware-reconfigurable network architecture integrating various computing resources including machine learning components.

- Proposed three levels High Performance Computing Architecture can be vied as specialized functional networks of stream data processing nodes with storage class memory recourse that forms distributed storage-calculation field and intelligent interconnection infrastructure.

- Due to flexible architecture are able to meet the requirements of particular tasks, such as: data structures, calculation algorithms, real-time requirement and etc., and allow to solve particular tasks more efficiently [14], [15], [16] in terms of Power Efficiency (FLOPS/W), Calculation Efficiency (Real FLOPS/Peak FLOPS) and Size Efficiency (Real FLOPS/square).

Conclusion : intelligent does not mean digital



Metaphors for the issue under discussion

Мышление есть лишь расчет.

Томас Гоббс (1588-1679)

Не будем спорить — давайте посчитаем.

Жозеф Лагранж **(1736-1813)**

«Интеллектуальная» регуляризация

- Одна и та же система проявляет различные физические свойства в зависимости от имеющейся о ней информации (в одном случае система способна совершить работу, в другом – нет)
- Мера информации оказывается согласованной с общефизическими понятиями энергии и энтропии
- Информация как описание состояния системы наравне с ее физическими параметрами меняет ее свойства. Т.е. в зависимости от имеющейся информации о системе систему можно или нельзя использовать для совершения работы. (в одном случае система способна совершить работу, в другом – нет)