
http://hipeac.net/vision

# HiPEAC Vision 2021- Software focus:
## Composability, Properties contracts and Orchestration Systems

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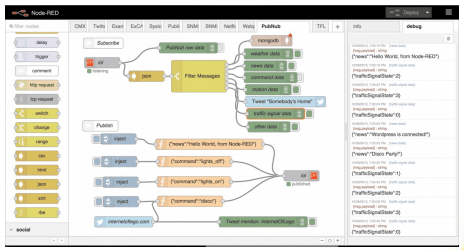
# Evolution of ICT (from user point of view)

Less use of web browsers, instead specialized Apps for each ***service*** (e.g. App from an Hotel to *book a room*)
**Aggregators** apps to select the service (e.g. Booking)
Even Aggregators of aggregators (e.g. Kayak)
…
**Overflow of information**, of choices, etc.…
Industry/users only want "***services***" selected according to their requirements

More natural and contextual interfaces (AI)

Using more "natural" interfaces: voice, drawing, gestures, …
Aware of the environment
Adapt input and output to the situation



***"Natural" programming: Glueing together "services" local (libraries) or remote by scripting languages (e.g Python), voice, specifications, graphical, by example, …***

# IN MARCH TOWARD HETEROGENEITY

- Processor hardware architectures are becoming **increasingly heterogeneous**
  - Different accelerators and instruction sets – ISA- (x86, ARM, RISC V, …)
- This trend acknowledges the benefit of specialization and opportunistically leverages a variety of specialized accelerators in order to **increase efficiency**
- The overall computation becomes the **orchestration** of specialized code deployments on specialized accelerators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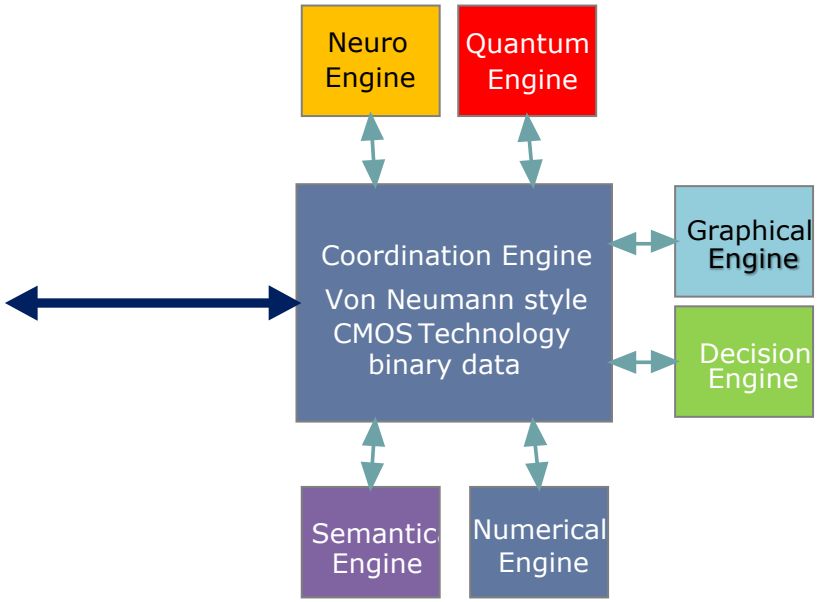
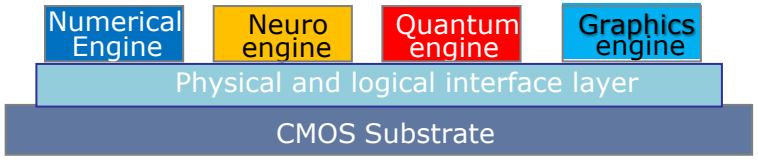
# FUSING PARADIGMS

**At the hardware level, the good old Von Neumann/ CMOS partnership can act as a computing substrate, or orchestrator of various accelerators/technologies**

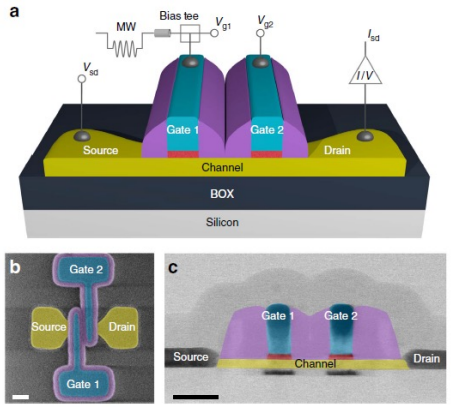
- Acting as coordination / communication node
- Allowing Hardware / Software integration

***How to ensure interoperability of different computing paradigms and information representations (bits, "spikes", Qbits, ….) ?***



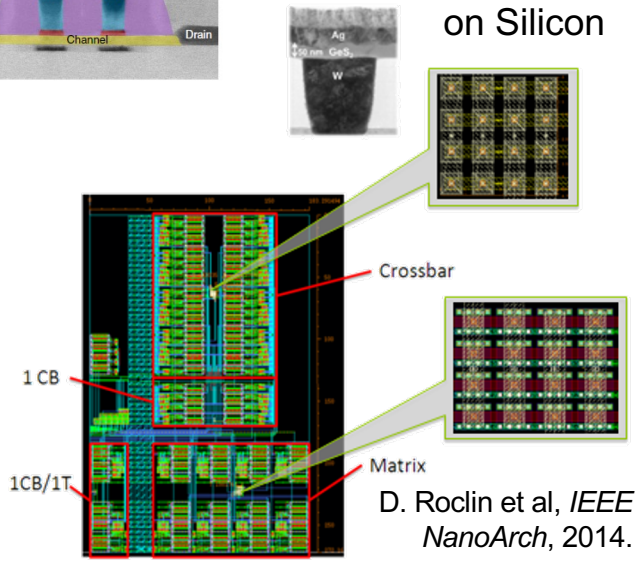

Slide from Christian Gamrat




Qubits on Silicon

Maurand et al, *Nature Com.*, Jul. 2016.

NVM Synapses on Silicon




D. Roclin et al, *IEEE NanoArch*, 2014.

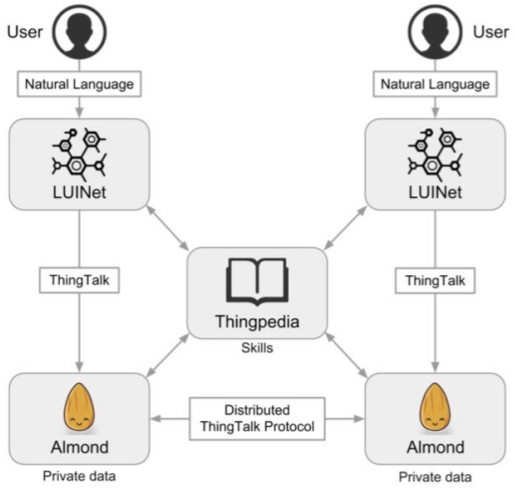
# AND THE SOFTWARE FOLLOWS …

- Much the same is happening for software applications
- Opportunistic aggregation is **the most practical way** to draw the most value added from a variety of heterogeneous specialized parts, from cloud to fog to edge
  - Heterogeneous software technology and heterogeneous targets
- The **overall application logic orchestrates** the individual parts (“services”, libraries)
  - It could be the “orchestrator” that “gets” the “skills”, “service” or knowledge from repositories/libraries.
  - The “orchestrator” logic might be created by “linguistic programming” using natural language or other natural ways of giving specifications.

***2 “levels” of software:***

- ***The services, libraries, that should be efficient, correct by construction, using formal proof if possible, …***
- ***The composition (orchestration) building the application that should be easily done by users or automatically done following user’s specifications and***

***Nb: the “orchestrator engine” should be trustable and should run on a trusted platform***




Giovanni, Xu, Ramesh, Fischer, Lam, Ubicomp 2018

c.f Stanford’s Almond project
https://almond.stanford.edu/

# HOW TO SELECT THE SERVICES ?
# FULFILLING CONTRACT OBLIGATIONS VERIFIABLY

- In order for the composition of containerized SW parts to produce **trustable applications**, the implementation of each part must demonstrate satisfaction of the guarantees set on it (= the **contract**)

- This requires programming languages and tools that understand and explicitly support and **expose functional and non-functional properties such as time, latency, localization, privacy, cost, energy, QoS, …**:
  - *Required to optimize power, timing constraints, etc…*
  - *Required to have trustful **Cyber Physical Systems** (systems which interact with the physical world), like self driving car, automated factories, etc…*

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# THE CLOUD-FOG-EDGE CONTINUUM

- Once we have containerized SW parts and rapid deployment, we want to **run them opportunistically anywhere** on the continuum of computing **where it is best** according to
  - Power and energy budget
  - Storage and CPU resources
  - Latency and privacy requirements
  - …


- **This opportunistic mobility can be seen as a sort of "*write once, run anywhere*" motto made truly universal**
  - Which does not prescribe interpreted execution or single-language implementation
  - Not only data, but also **code can move** if it is more efficient

- Edge nodes must be able to accommodate some of this deployment so that value added may shift toward them
  - "Intelligent orchestrators" can be the interface between the user and the continuum to cope with **complexity**

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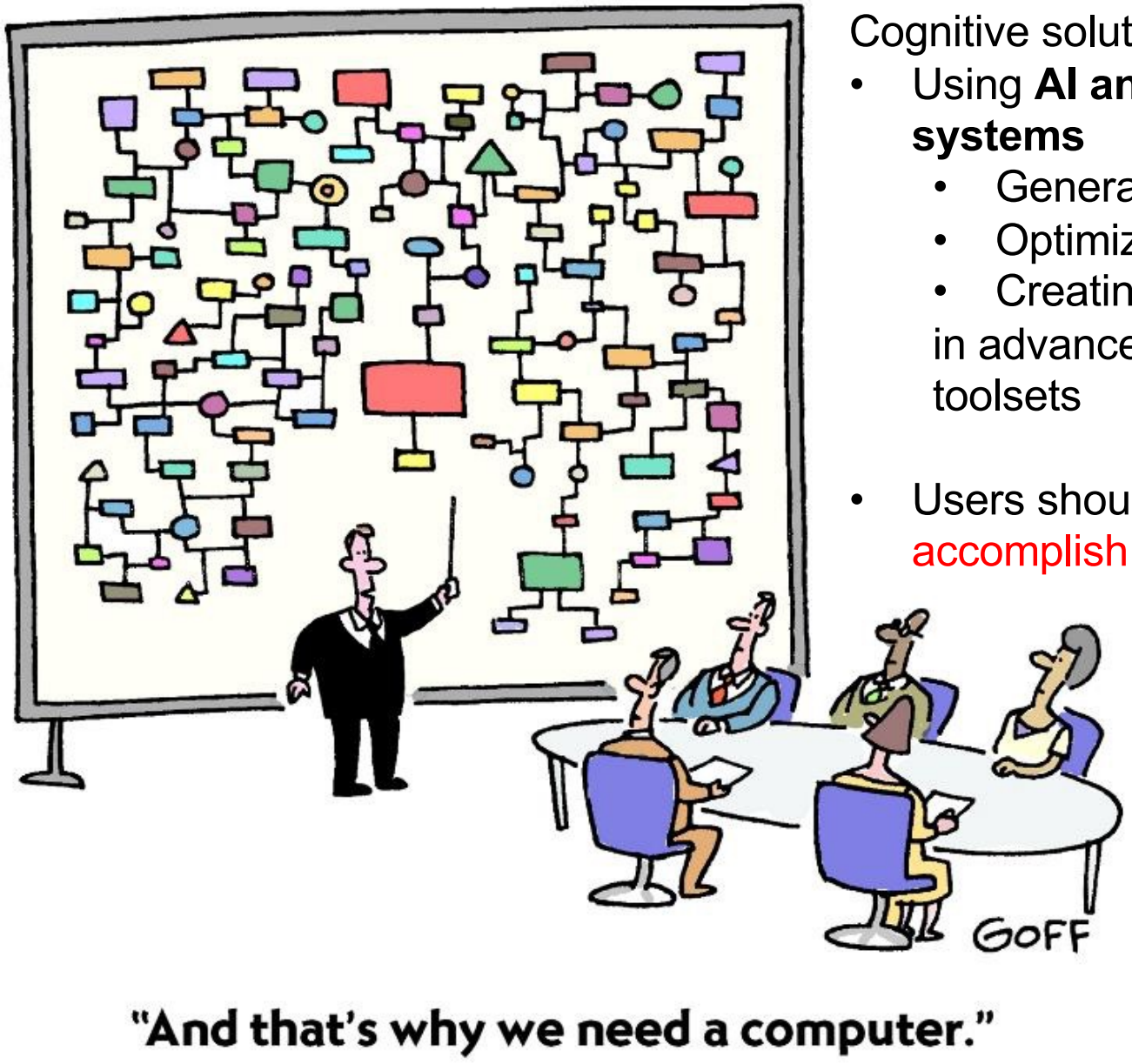
# MANAGING COMPLEXITY

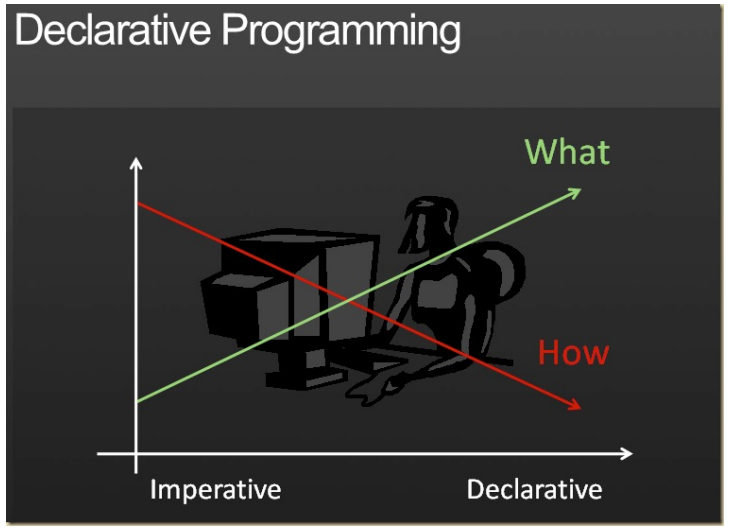



Cognitive solutions for complex computing systems:

- Using **AI and optimization techniques for computing systems**
  - Generating code
  - Optimizing systems
  - Creating new hardware

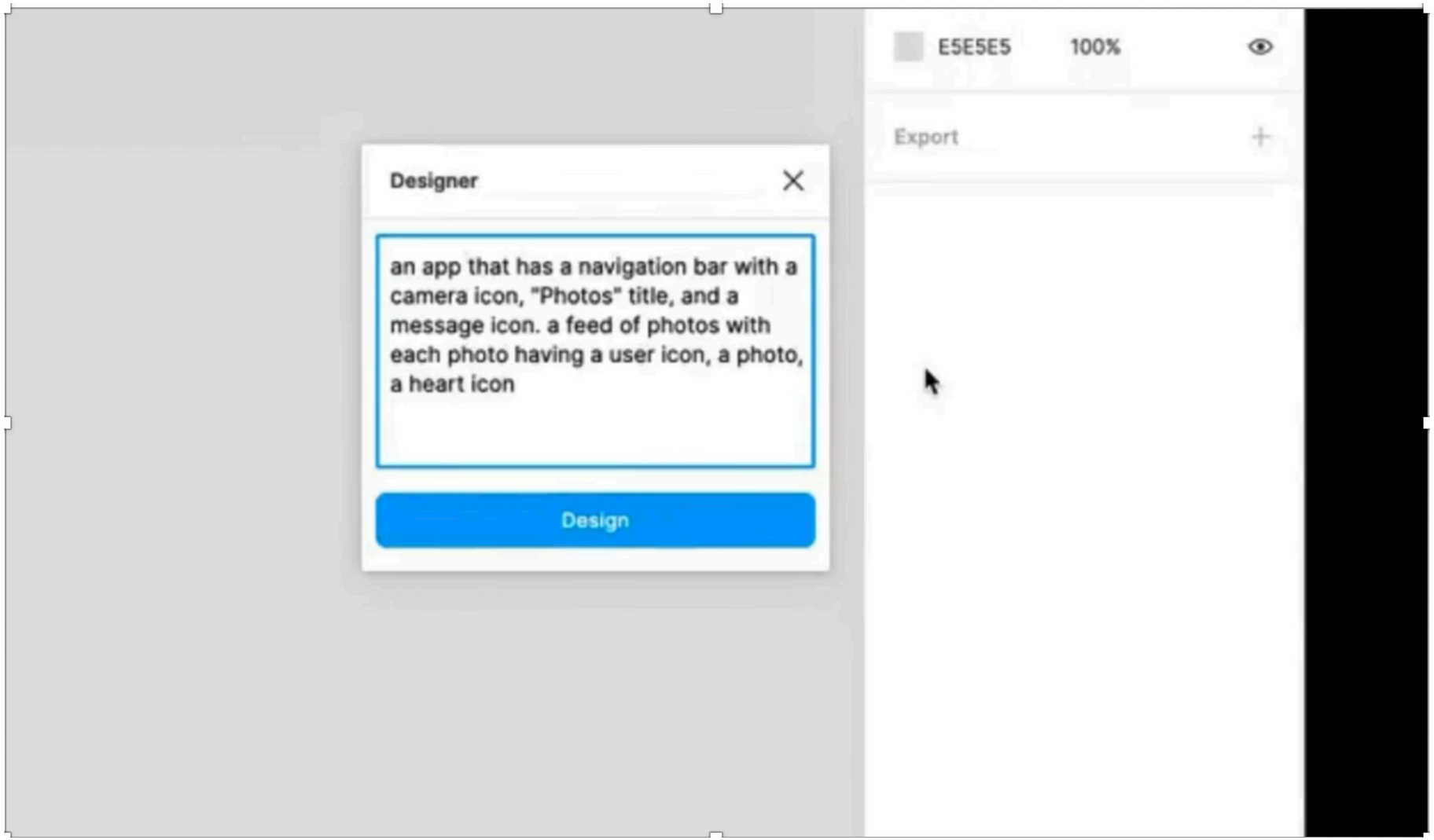
  in advanced, transparent, easy to use and interactive toolsets

- Users should describe ***what*** the program/system should accomplish, rather than describing ***how*** to accomplish it




From Hipeac Vision 2017

# OPENAI'S GPT-3, EXAMPLE OF CODE GENERATION FROM NATURAL TEXT




* https://www.youtube.com/watch?v=8psgEDhT1MM

The back page of the document is a summary of the key recommendations

# Key recommendations of the HiPEAC Vision 2021

We have come a long way from the time when a computing system consisted of one computer core programmed in one or very few programming languages. The need for more computing power on energy constrained computing platforms (from deep edge sensor node to supercomputer) first forced computer vendors to introduce multicores. More recently it has obliged them to leave behind homogeneous multicores in favour of heterogeneous multicores consisting of different kinds of accelerators that are more efficient, but more difficult to program and use efficiently.

The emergence of new workloads such as deep learning and large-scale industrial cyber-physical systems has led to a series of new challenges that are related to non-functional properties including power consumption, timing, complexity, security, safety and sustainability. The design and implementation of modern computing systems has become so complex that it exceeds the cognitive capacity of even the best computer scientists.

Therefore, HiPEAC recommends that we move towards 5S.(CPS)$^2$:

**Cognitive Cyber and Predictive Physical System of Systems**
**that are**
**Sober, Secure, Safe, Straightforward and Sustainable.**

**The recommendations of this 2021 Vision are:**

**Cognitive**: HiPEAC recommends investing in ultra-low power accelerators for AI and in the investigation of approaches that use less labelled data.

**Cyber**: Just as Europe set the basis for the world wide web, HiPEAC recommends that it should secure its place at the forefront of the "next web" by adding the necessary innovations and standards on top of existing technologies to meet and satisfy human needs and interests.

**Predictive**: HiPEAC recommends investment in digital twins and models that can be executed accurately and efficiently at the edge.

**Physical**: HiPEAC recommends investment in research into ways to correctly model non-functional properties and to guarantee them in the systems.

**System of systems**: HiPEAC recommends investment in systems of systems research and in development of tools for orchestrating large dynamic heterogeneous systems.

**Sober**: HiPEAC recommends investment in the development of ultra-low power computing platforms covering the complete digital continuum, and in tools allowing assessment and design of systems with explicit power constraints.

**Secure**: HiPEAC recommends that more investments be made in cybersecurity research, and in particular in the automated finding of security risks, in the means to automatically mitigate or remove those risks, and in the development of secure hardware and tools that can produce secure by design software and hardware.

**Safe**: HiPEAC recommends further investment in research and development in the methodology and design of safety-critical systems.

**Straightforward**: HiPEAC recommends the development of approaches that improve human productivity to design, produce and manage complex systems, including with the use of AI techniques.

**Sustainable**: HiPEAC recommends that Europe funds research to lower embodied energy of devices, and encourage the extension of the lifetime of devices by upgrading, reusing and repairing them. Europe should have the ambition to lead in the design of sustainable electronics.

**Open source**: HiPEAC recommends investment in free open source digital commodities in the form of an EU platform that can be used by third parties to create value. This requires the establishment of a dedicated European institute or hub to support open source.

**New computing technologies**: HiPEAC recommends that Europe continues to investigate emerging technologies, not with a view to them directly replacing silicon technology, but to complementing it. This research should be wide-ranging, and include new ways to code information (e.g. using "qbits", or temporal coding like with "spiking" neuromorphic architectures, or using physics phenomenon – like light – as analog computing approaches), as well as methods to efficiently integrate these approaches as "accelerators" in a silicon technology-based system, on both the hardware and software sides.

**Moonshot programme "Guardian Angels"**: HiPEAC recommends the creation of a "Guardian Angels" moon-shot programme that encompasses all the 5S.(CPS)$^2$ technologies into a system that will serve European citizens and companies.

**International competence centre**: HiPEAC recommends the creation of a well-funded European competence centre in computing so that Europe is able to retain and attract top talent, to set its own ambitious research agenda, and to defend its position as a scientific powerhouse in computing.

**Digital infrastructure**: HiPEAC recommends European investment in a state-of-the-art digital infrastructure.

**Training**: HiPEAC recommends European investment in education and lifelong learning, with a view to producing more highly-skilled computer scientists to advance the state of the art in 5S.(CPS)$^2$ in all its aspects.

**Innovation culture**: HiPEAC recommends greater European investment in the creation of an innovation culture at all levels (education, society, industry) to stay competitive and to help attract venture capital for startups and scaleups.

**European values and digital ethics**: HiPEAC recommends that every individual be guaranteed the same protection in the cyber world as they are in the physical world. Digital ethics should become part of business practice.

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# RATIONALE FOR A SYNERGISTIC PROGRAM ACROSS DOMAINS

- **Continuum of Computing (from IoT to Cloud)**
  - Interoperability, Virtualization, Scalability
  - Build on top of existing technologies/standards
- **"Write once, run anywhere"**
  - (Micro) Containers for legacy and migration of code (and less data)
- **Link with the physical world (CPS and IoT) and its constraints (safety,..)**
  - Exposing non-functional properties (time, power, latency, cost…)
  - Contract-based services (e.g. using REST-API)
- **EaaS (Everything as a Service)**
  - Dynamic selection and orchestration of distributed services
  - *Trustable Open Smart Orchestrators* running on a trusted computing base
- **Cybersecurity everywhere**
  - Trusted execution platform *loyal to its user*, not to the provider
  - Correct by construction, use of formal methods and proofs
- **Controlling in-bound and out-bound data (Privacy)**
  - Detecting fake/rogue data
  - Protecting corporate data and privacy
- ***Using natural interfaces (e.g. voice) and context awareness***
  - "Natural programming" or "No-Code" software, or generated from specs
  - More natural interfaces (graphical, voice, gestures, imitation, …)
  - Interactive, with feedback, "man in the loop"
- ***Edge processing (use of local resources, sharing computing/storage)***
  - Federation of local resources (computing, storage)
  - Running on European trusted hardware platforms

Moving code and not only data

A paradigm unifying technical solutions intertwining Cyber and Physical worlds (*ICT* + *IoT/actuators*) for ***industrial*** and personal use

Based on existing technologies

It is a ***holistic approach*** to build a complete *European ecosystem & infrastructure* using the current European strengths

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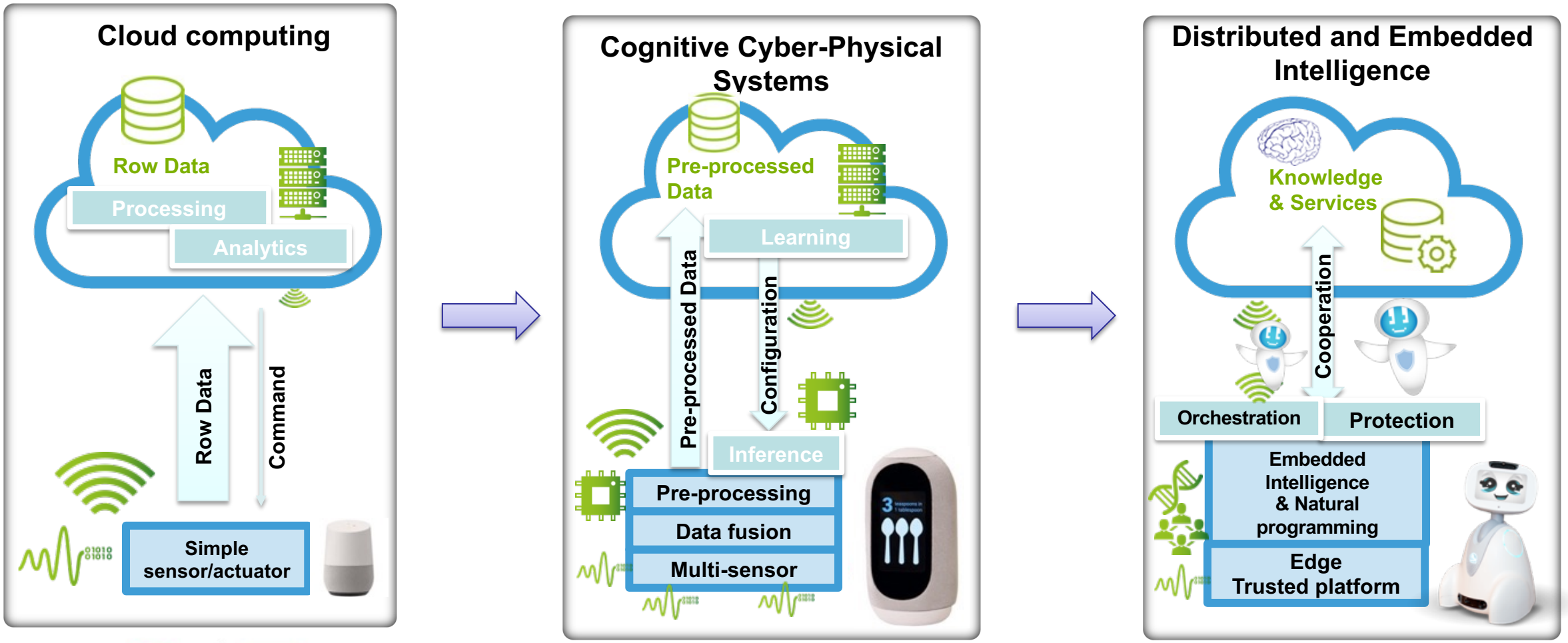
# CONCLUSION: EVOLUTION TOWARDS EMBEDDED INTELLIGENCE ORCHESTRATED AND SECURED BY SMART ORCHESTRATORS




2021 model

Edge AI

AIoT

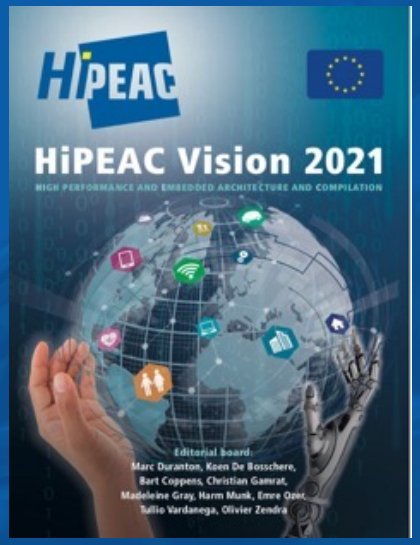
Artifical Intelligence of Things

Federation of Open Smart Trustable Orchestrators

Original idea of the slide from Denis Dutoit (CEA)

Thank you

More information available from

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