Since 2004, HiPEAC has provided a hub for European researchers and industry representatives in computing systems (HW and SW).

Orchestrating the Edge: the "Guardian Angel" concept

IoT and Edge Computing: Future directions for Europe

HiPEAC vision 2021 editorial board

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Vision on the evolution...
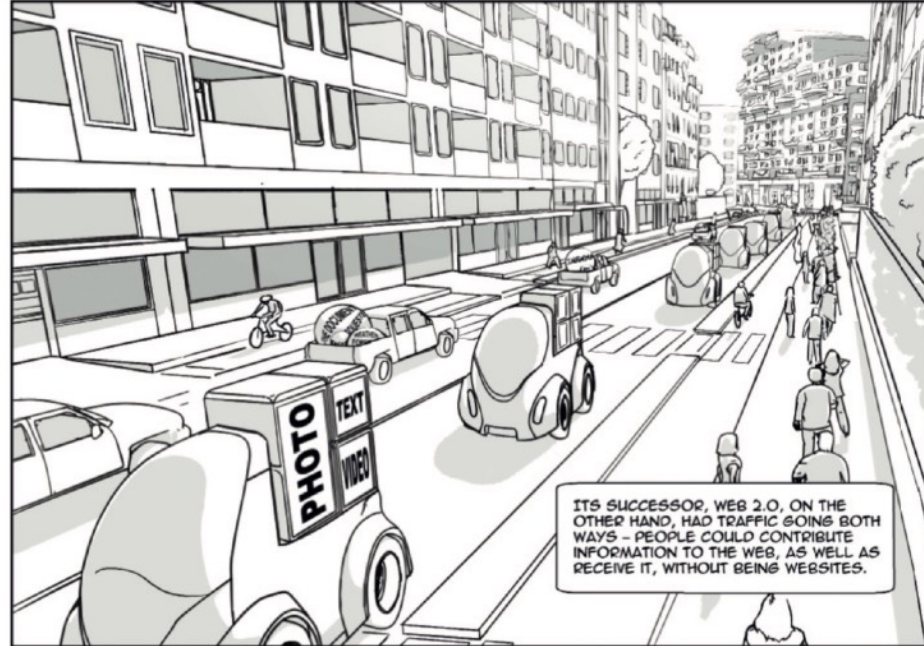# … of the Web and of IoT

Evolution of the WEB

Web 1.0: One way road: Contents and presentation imposed

Web 2.0: Bidirectional contents
Presentation imposed

Evolution of the WEB

Less use of web browsers, instead
Specialized Apps for *services*
(e.g. App from an Hotel to *book a room*)
Aggregators apps to select the service
Even Aggregators of aggregators
…
Overflow of information, of choices, etc.…
Industry/users only want "*services*"
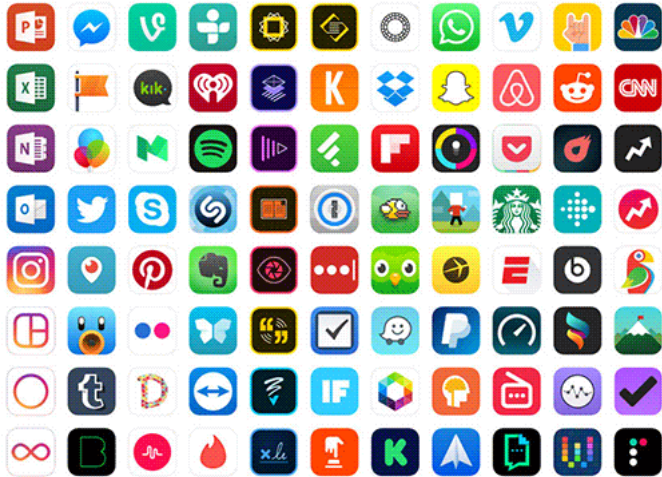
More natural and contextual interfaces (AI)
Aware of the environment
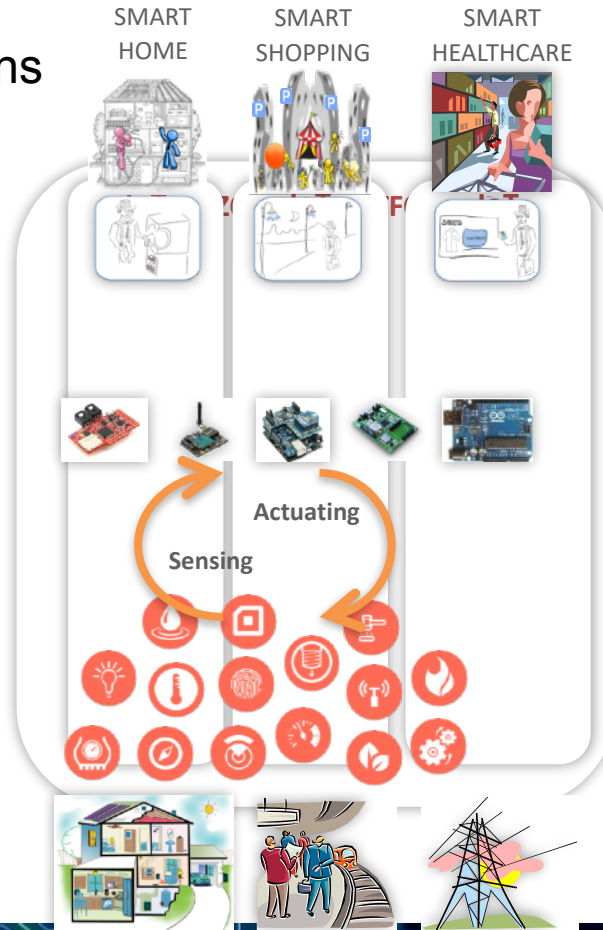Adapt input and output to the situation

Horizontal Iot Platform

Various application/industry domains
Domain specific Platforms
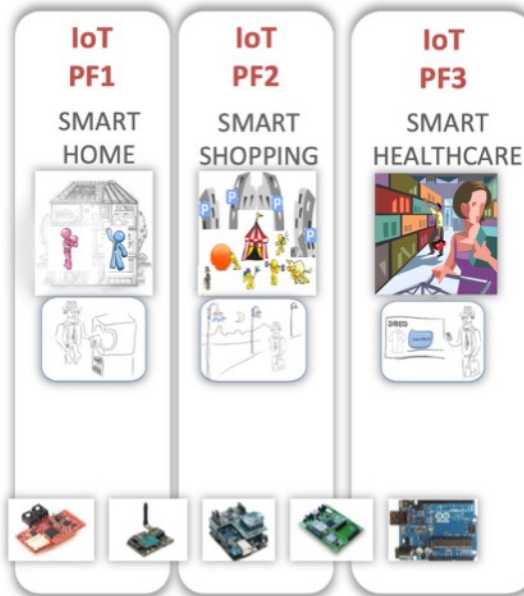(also company specific)

Heterogeneous IoT devices

Heterogeneous physical quantities

Heterogeneous physical world

SMART HOME

SMART SHOPPING

SMART HEALTHCARE

Actuating

Sensing

"PROGRAMS", "APPLICATIONS"
NOW ARE EXECUTED IN THE "CONTINUUM"

MULTIPLE DISTRIBUTED FUNCTIONS
(SERVICES)
+ GLUE (ASSEMBLING, ORCHESTRATING)
= THE "NEW" PROGRAM STRUCTURE

Even at programming level
E.g. Python
(glue between specialized libraries)

- This initiative currently involves:
  - ETP4HPC, ECSO, BDVA, 5GIA,
  - EUMATHS, CLAIRE, HiPEAC…
  - More to come…

The Digital Continuum

Cybersecurity

Cyber Physical systems

Smart sensors & IOT

HPC/ Cloud

Artificial Intelligence
Math. Models & Algorithms
Processing, protecting, abstracting, understanding *as soon as possible*

Data analytics / Cognitive computing

Smart Networks & Services

BigData

Edge processing, Fog, …

TransContinuum Initiative (TCI):
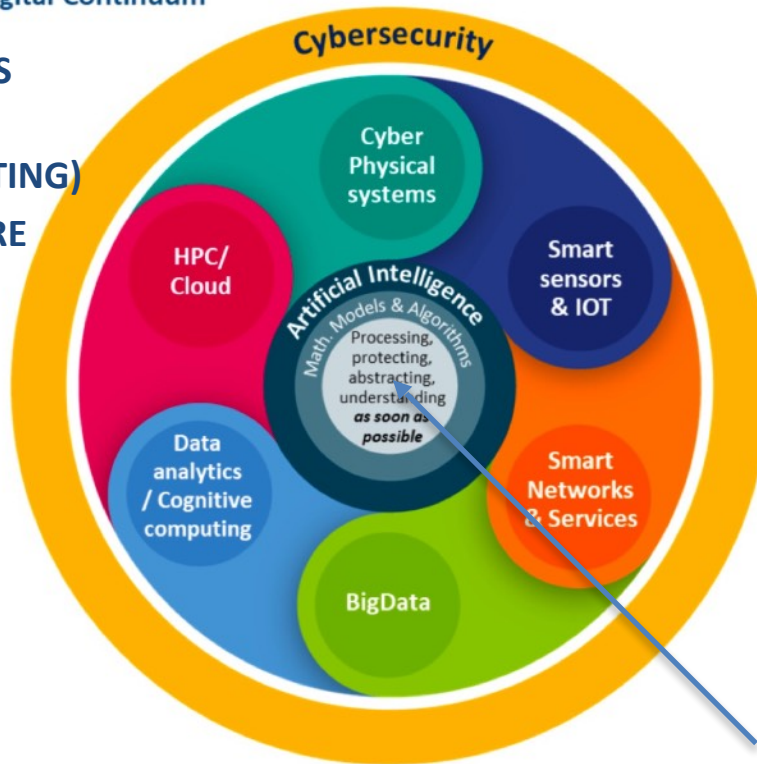
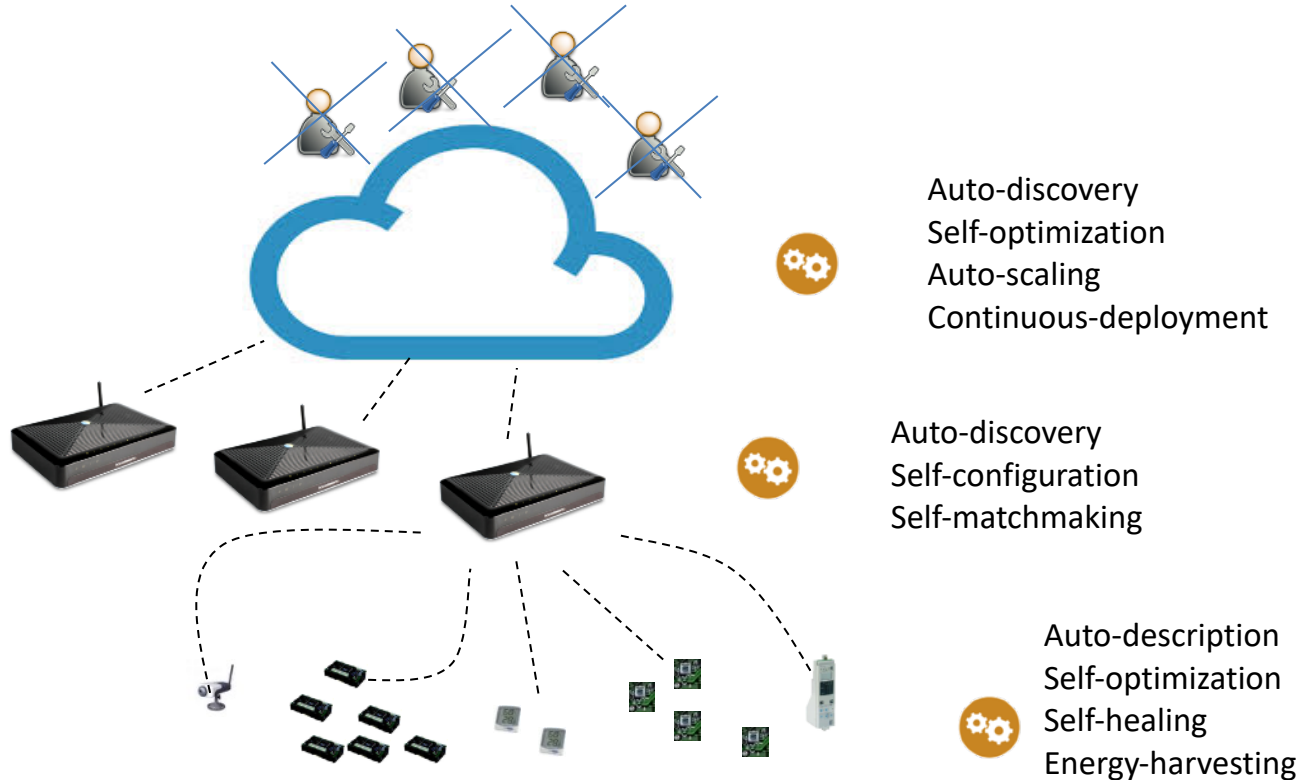## A continuous dynamic workflow

Between
**Smart Sensors
and IOT devices at the edge**
and
HPC / cloud centers
over
Smart Networks and Services
executing
**Simulation & Modelling,
Big Data Analytics, ML***
based on
**Math. Methods & Algorithms incl.
MSODE****
pervasively augmented by
Artificial Intelligence
protected and secured by
Cybersecurity
back to
Cyber-Physical Systems

Plug&play, self-management, orchestration with (virtually) no human intervention

Auto-discovery
Self-optimization
Auto-scaling
Continuous-deployment

Auto-discovery
Self-configuration
Self-matchmaking

Auto-description
Self-optimization
Self-healing
Energy-harvesting

The challenge: Interoperability and Composability (Orchestration)

Overcome the fragmentation of vertically-oriented closed systems
Move towards open platforms and standards.

Heterogeneity/Interoperability
How to handle the numerous types of devices, protocols, standards, *non functional requirements*?

Scalability
How to handle the big number of connections/big data coming from millions of devices?
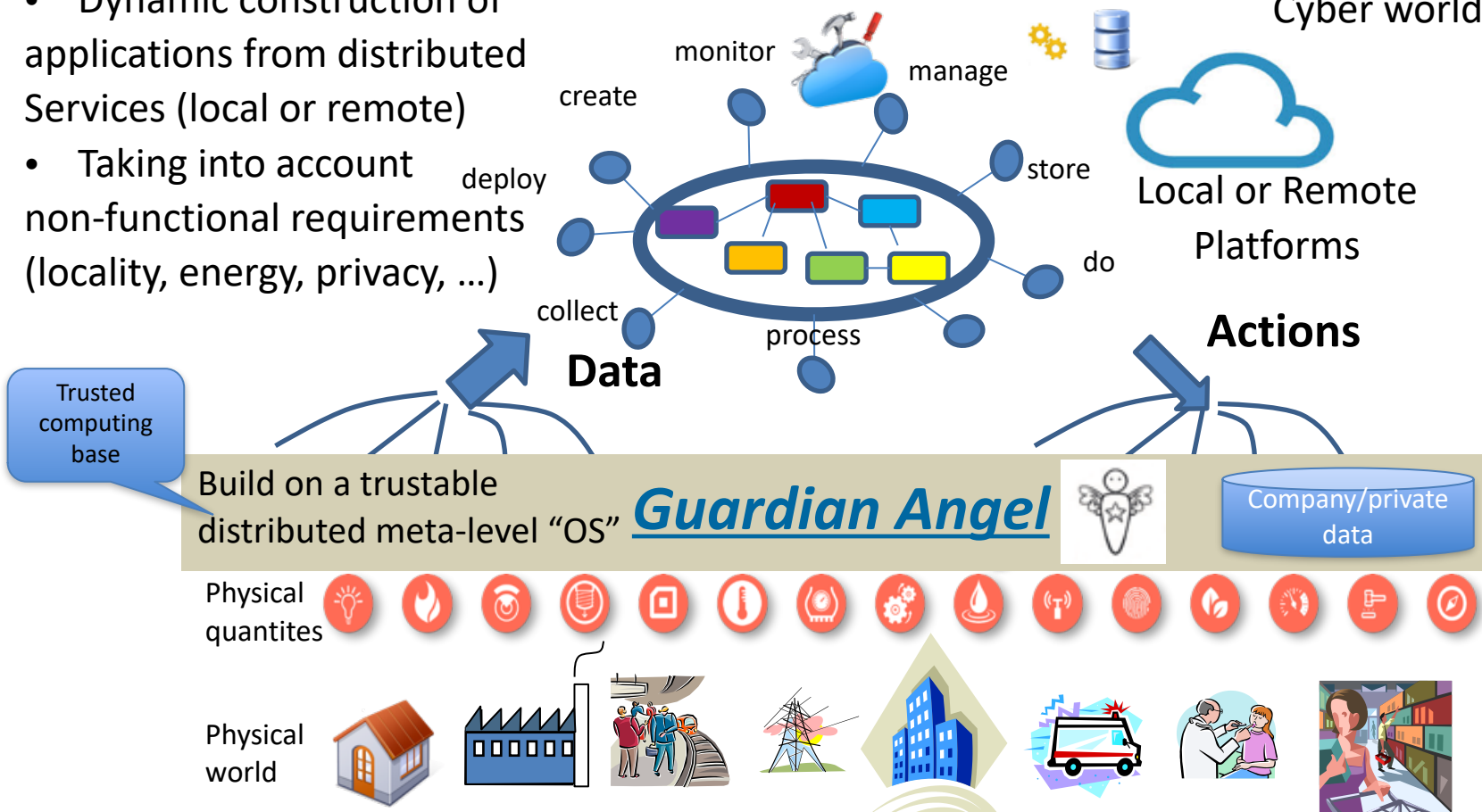
Dynamicity
Plug&play, self-configuration, self-management, self-matchmaking

Privacy Ensuring that the confidential data of the company, the individuals don't leak

Creating the *next Web*,
Intertwining
Cyber and Physical worlds
for industrial and personal use
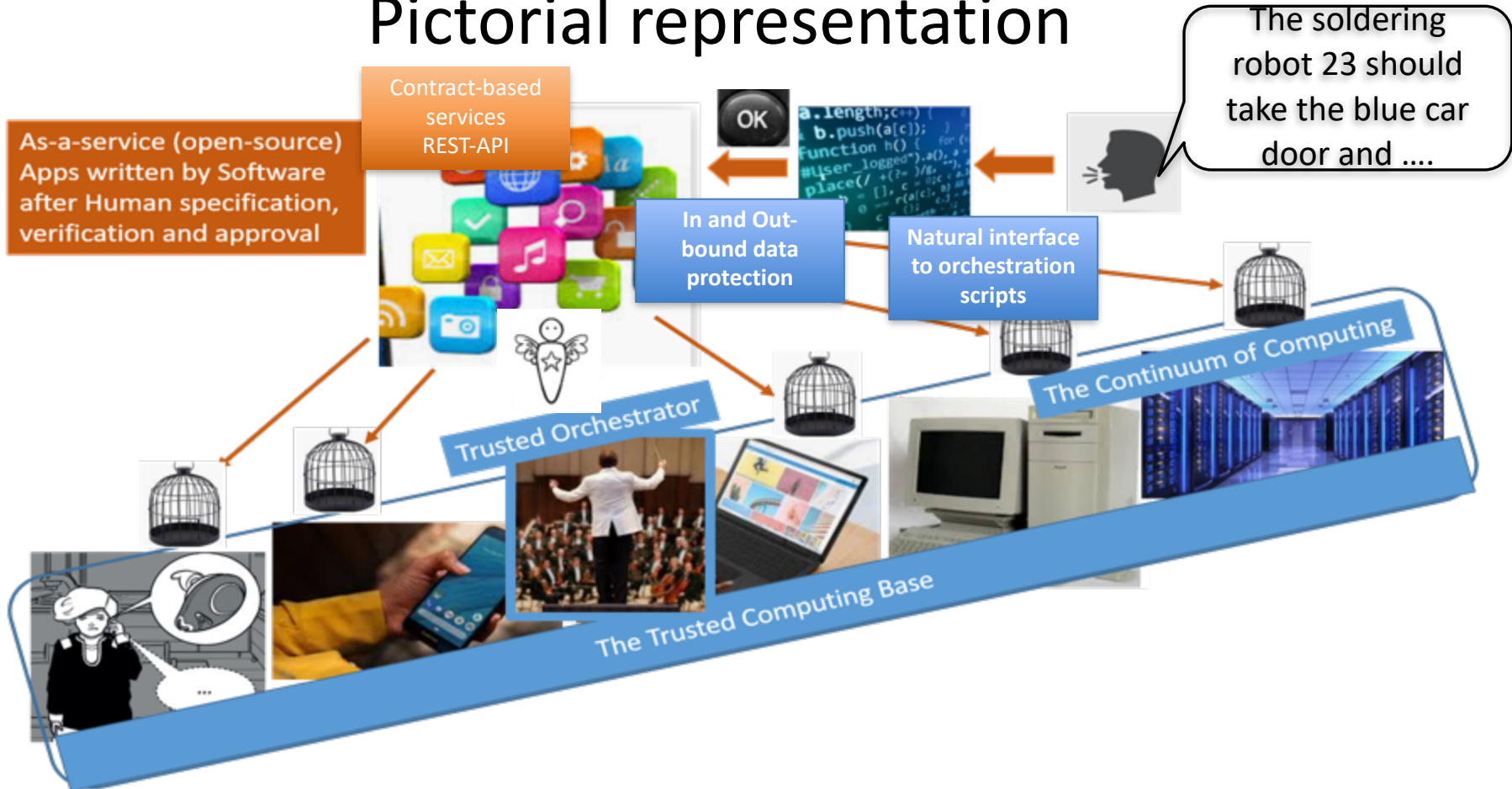*Build on top of existing technologies*

- Dynamic construction of applications from distributed Services (local or remote)
- Taking into account non-functional requirements (locality, energy, privacy, …)

monitor

create

manage

Cyber world

deploy

store

Local or Remote Platforms

do

collect

Data

process

Actions

Trusted computing base

Build on a trustable distributed meta-level "OS" *Guardian Angel*

Company/private data

Physical quantites

Running on edge hardware

Physical world

Hints on how to realize the "Guardian Angels"

Pictorial representation

Having software write software

- Application code should be written by software – humans should give specifications
  - Most such Apps will run on near-edge:edge devices, but also on traditional computers
- The Apps themselves, highly-mobile (not resident), serverless-like, and sandboxed, will aggregate other services
  - The communications and interactions needed for orchestration will all occur over-and-above HTTPS
  - The individual services candidate for orchestration will expose rich contract-based interfaces and will reside anywhere
  - The development of such Apps by orchestration will not need programmers, but programming engines capable of voice-and-artefact interaction with humans:
    - Humans will express requirements, preferences, and properties to be satisfied
    - Development will be iterative until satisfaction, sanctioned with (auto-generated) proof of compliance
    - They should be correct by construction

- Their execution environment (the Trusted Computing Base) will be an evolution of the engine of modern browsers without the display and rendering part.
  - The TCB will also allow orchestrating the activation and cooperation of Apps as needed
  - The TCB builds user preferences (adaptively) and preserve them against attacks, bias and tampering

Continuum of computing

- Continuum of computing: a uniform platform capable of hosting as-a-service software at the place most appropriate to the use(r) of it, for latency, resource capacity, etc.
- The continuum infrastructure is composed of two types of software
    - The TCB written, verified and validated (and approved by humans), and delivered in open source
    - The user-level Apps (resulting from orchestrating service), not written by humans, but produced by (virtual-assistant) software in response to oral or other natural way to express specifications and guided assisted iterations (including automated verification and validation) before delivery and use

- The platform of that continuum could be built as a trusted, principled, overlay over the current OS technologies: this will form the Trusted Computing Base (TCB)
    - It could entirely replace traditional OSes on the edge, where technology is less dependent on legacy
    - Open source, adherent to European values for data privacy and fairness, treated as a "public good"
    - The economic revenue of open-sourcing the continuum infrastructure should come from private enterprises developing and commercializing proprietary value-added services that run on the TCB but are unable to break and breach it

- The external interface of the continuum should be a flexible, configurable, programmable, orchestrator and aggregator of service Apps
    - Where Apps should be consumed in an as-a-service or serverless model (no need for installation)
    - With sandboxed execution, as with container-based microservices

- An emblematic notion of this continuum platform is a **constellation of cooperating personalized virtual assistants** running on edge nodes (handheld, wearable devices) near the user

Structuring European efforts: define a cross domain
moonshot project

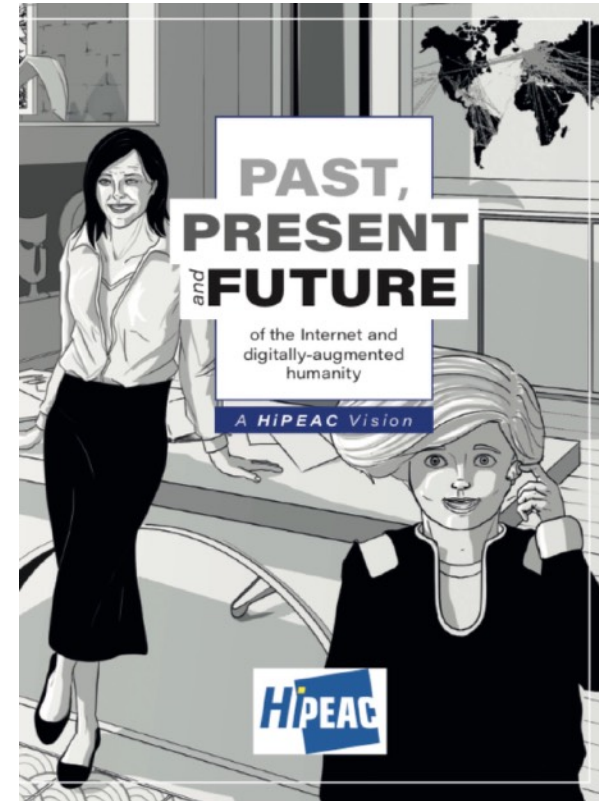Promote a collaboration that synergizes:
- Interoperability and a contract based approach
    - Contracts, assertions between entities
- Exposing non-functional properties
    - Managing the complexity (of choices)
- Controlling in-bound and out-bound data
    - According to user's profile(s)
- Edge processing and federation of local resources
- Open-source "orchestrator" and TCB
- Natural interfaces and context aware (using AI)
- "Natural programming" (for orchestration)
- Containers for legacy and migration of code/data
- "Supervisor" for non trusted/legacy parts
- Cybersecurity everywhere
- Running on European hardware platforms
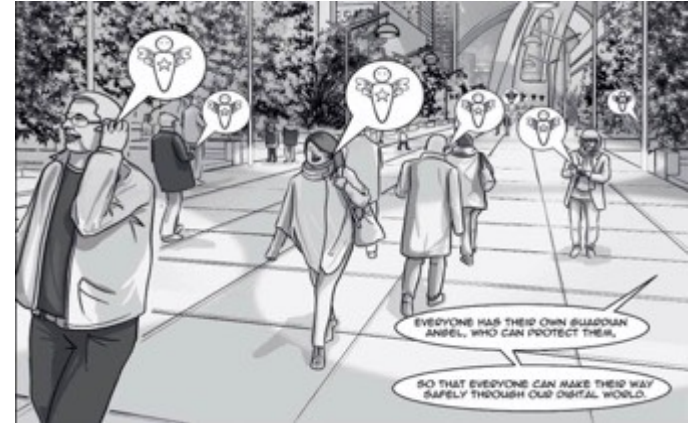
Past, Present and Future

For a more
fun introduction
of the concept of
Guardian Angels…

https://www.hipeac.net/media/public/files/46/7/HiPEAC-2019-Comic-Book.pdf