NETWORLD EUROPE

Strategic Research and Innovation Agenda Webinar
12-13 January 2023

FUTURE EMERGING TECHNOLOGIES

Anastasius Gavras

SRIA Webinar, 12-13 January 2023

OVERVIEW

- Attempt to name technologies outside of current lists of emerging technologies like the ETSI technology radar, or the Gartner hype cycle.
- Identified technologies with a low Technology Readiness Level (TRL) of typically 2, which means that the technology concept has been formulated, is exiting basic research and entering the phase to prove its feasibility.
- Impact on Europe values and linking to European inventors and innovators ecosystem.
- A view on the potential impact on the UN Sustainable Development Goals (SDGs)
- Identification of unresolved issues

LIST OF TOPICS (1)

- Quantum technologies: networking, communication, computing (related to telecoms) machine learning
- Security: Scalable homomorphic encryption
- Human centric multimodal communication: Entangled human interaction with devices and physical objects, Holographic sense, Augmented human cognition through implants or non-invasive, Disappearance of the smartphone
- Digital twinning applied to 6G

LIST OF TOPICS (2)

- Nano, bio-/molecular technologies and communications
  - Bio-degradable and digestible sensors and actuators; Degradable sensors and actuators needed in inaccessible places (oceans, woods, sewage); Chemical and biological level
  - 3D printing of bio-degradable, digestible sensors and actuators; 3D spraying, e.g. spraying reconfigurable intelligent surfaces on building walls (not elaborated in technical annex)
- Energy, green house gas impact, total cost of ownership in terms of energy and resource cost; Energy harvesting from the environment; (near-)Zero energy devices
  - How to measure, monitor, enact energy and resource targets?

QUANTUM REALM

- Quantum key distribution is not a FET
- Quantum computers are rapidly emerging; open research topics on how to interface and use them (software frameworks and software tools)
- Quantum communication, e.g. used in Quantum Key Distribution; open research topics on reliability and efficiency, as well as on how to use quantum communication for interconnecting quantum computers
- Modular-quantum computers composed of several connected quantum computer chips; current state-of-art is to revert to electronics

SCALABLE HOMOMORPHIC ENCRYPTION

- Computation is carried out directly on ciphertext. The result of the computation is left in encrypted form which, when decrypted, results in an identical output to that produced had the operations been performed on the unencrypted data.
- Homomorphic encryption is privacy-preserving for outsourced storage/computation
- Simple examples demonstrated; scalable solutions suffer performance degradation
- Solutions depending on hardware (TEEs) are vulnerable to side channel attacks
- The research challenges pertain to identifying alternative approaches to remove the scalability barriers for full homomorphic encryption

HUMAN CENTRIC MULTIMODAL COMMUNICATION

- eXtended Reality and holographic telepresence are mainstream research; however mostly cover audio-visual; not suitable for interaction and real world manipulation
- Touch, taste and smell at distance are further senses that can be integrated; virtual “teleportation”?
  - Touch is within reach (tactile Internet); Taste and small depend on chemical reactions and their transposition depends on the presence of chemical elements available at the remote end, and assuming we understand how to trigger chemical reactions
- Augmented cognition through implants or non-invasive (brain computer interface)
  - Retina implants exist in research, mainly for medical reasons; but we could potentially replace displays all together; substantial ethics and security issues

ENTANGLED PERSONALITY

- Facebook's metaverse (originally coined in 1992), the concept of avatars, holographic senses and augmented cognition realise a form of entanglement of physical objects and humans with their respective virtual representation
- Interaction takes place in the real world or the virtual world and is transposed across the two worlds, blurring the borders
- Can we call this scenario "Real Virtuality"?

THE DISAPPEARANCE OF THE SMARTPHONE

- Ambient voice recognition in private and public space, or in-ear headsets
- Global interconnection of all human-computer interfaces available in a space can provide an intelligent ambient, where the physical smartphone becomes obsolete and is virtualised in the cloud as the personal communication endpoint
- The challenges pertain to scaling, trust, confidentiality and economical viability
- Transporting the interface of the (global) computing system into “the air” is possible; Relying on availability of trusted interfaces everywhere, for everyone is a step too large for the current ecosystem; Profound dependency on infrastructure design and regulatory changes; Completely rethinking secure software design

NANO, BIO-/MOLECULAR TECHNOLOGIES AND COMM…

- Applications exist, but how do we interface to this world?
  - abnormality detection in blood vessels with mobile nano-machines; “swallow your surgent”…
- Basic functions (storage, computing, sensing, actuation) at this level are initially understood; Networks at this level are relevant for expanding the capabilities of single nano-machines or molecular building blocks.
- Interfacing via electromagnetic waves generated by electro-mechanically resonating nano-materials has been demonstrated, but remains a challenge for the next years
- Direct impact on species and the environment; beware of the ethics dimension
- Artefacts are at the 100 nm scale; Quantum effects become relevant

ENERGY HARVESTING DEVICES

- Main applications in environmental monitoring of production environments (temperature, humidity, shock exposure...) and monitoring the environment: flora, fauna, pollution etc.; Low-cost, zero-energy devices are needed.
- Typical energy levels that can be harvested are in the µW range (when harvesting RF energy); about an order of magnitude lower than what is needed for a conventional transceiver
- The extremely limited energy supply limits the amount of data that can be transmitted; mostly as low as a couple of bytes
- Need to rethink security; encryption of conventional device IMSI costs several orders of magnitude more energy than could be harvested

ENERGY AND IMPACT ON POLICY AND SDO

- Address energy efficiency with concrete actionable interactions with the system
  - Ability to query the system on the expected energy consumption of a provisioned service; Enact upper limits for the energy use of a service; Provide indications about how much QoS degradation one is prepared to accept for a give upper bound of energy consumption
- An electric vehicle consumes, say, 15 kWh/100km; How much additional energy is spent for the same car in a CCAM scenario per 100km? How about a 3’ phone call?
- Needs: Models, mechanisms and interventions to increase energy efficiency; Metrics to capture energy consumption of resources in highly distributed, virtualised environments; Instrument the models with standard interfaces; Specify the relationship of energy consumption with service KPIs and related KVIs

SUSTAINABLE ICT

- From an environmental and European sovereignty perspective, sustainable ICT must consider use of primary materials and resources beyond CO_2 and GHG emission
  - Health/environmental effects in production due to toxic materials and heavy metals; use of large amounts of ultra pure water in semiconductor production…
  - Recycling of e-waste must be planned in design phase. Some materials have an excellent recovery rate (platinum); others cannot be recovered (arsenic, mercury, barium); other materials are sparsely available on earth (indium); other are subject to monopolistic global market structures (rare earths)

JEVONS PARADOX

- Technological progress that increases the efficiency with which a resource is used, tends to increase (rather than decrease) the rate of consumption of that resource
  - Postulated by William Stanley Jevons in 1865 in the context of consumption of coal
  - In our words: The more efficiently we capture, store and process data, the more data we capture, transmit and store.
- This phenomenon can easily jeopardise the efforts towards energy efficiency we undertake, if we consider the global total cost of ownership.

NETWORLD EUROPE

THANK YOU FOR YOUR ATTENTION

networldeurope.eu