



soc² **S**ystem **O**n **C**hip
Systèmes embarqués
et **O**bjets **C**onnectés

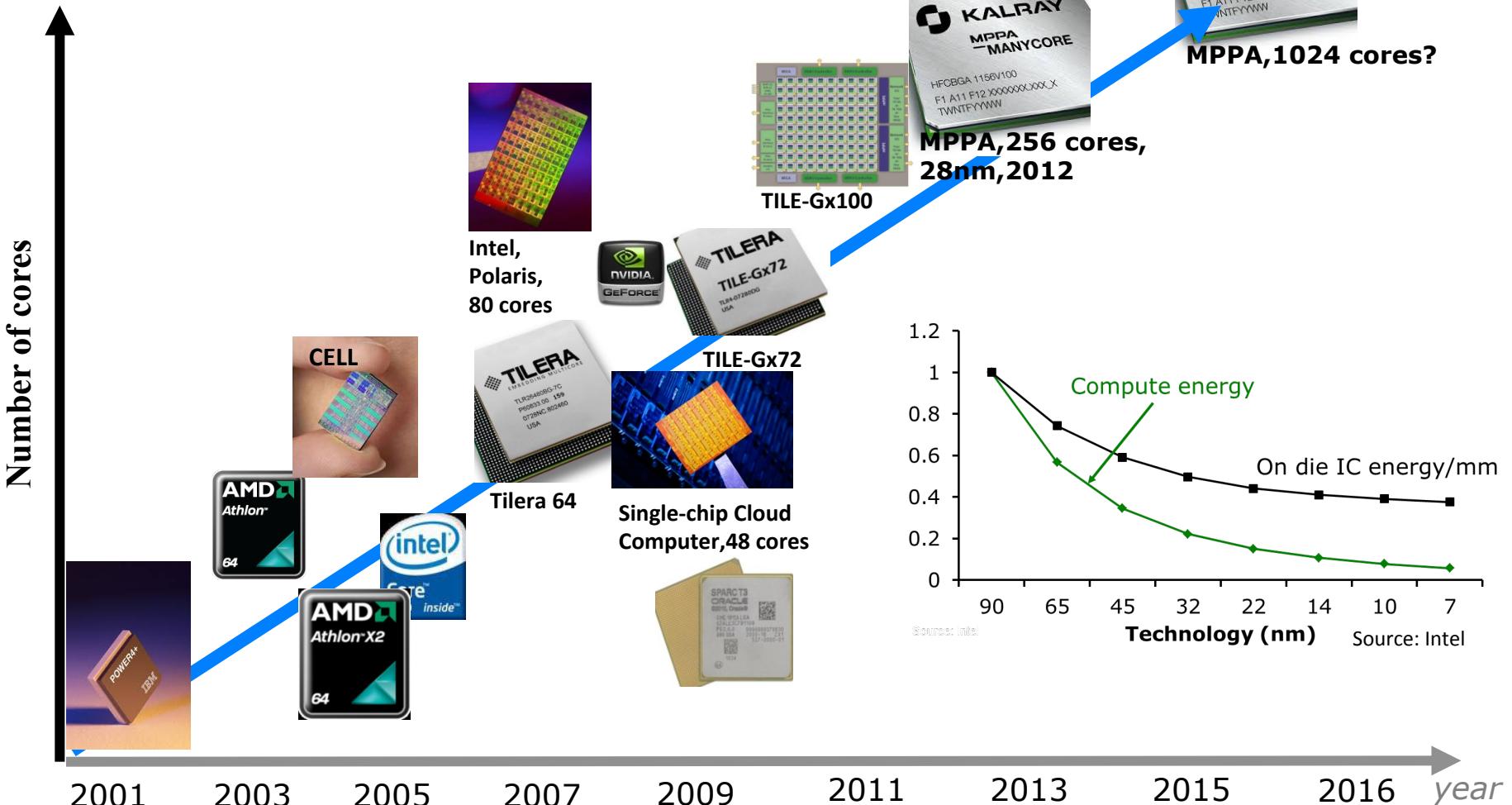
GdR SOC² **Axe Technologies du futur**

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Entering Kilo-Core Processors Era and Dark Silicon Era



Challenge: it costs more energy to move data (e.g., 1pJ/bit/mm) than to compute with them (e.g., 1 aJ/bit)

Axe technologies du futur

- Définition

- « Technologie » : *Agencement de matériaux et d'étapes de conception pour les dispositifs utilisés comme briques de base des SoCs.*
- « Briques de base » : permet de réaliser des **fonctions de calcul** (nanofils, nanotubes, SET, etc.), de **mémorisation** (MRAM, ReRAM, etc.) ou de **communications** (nanophotonique, terahertz, optique visible, etc.).

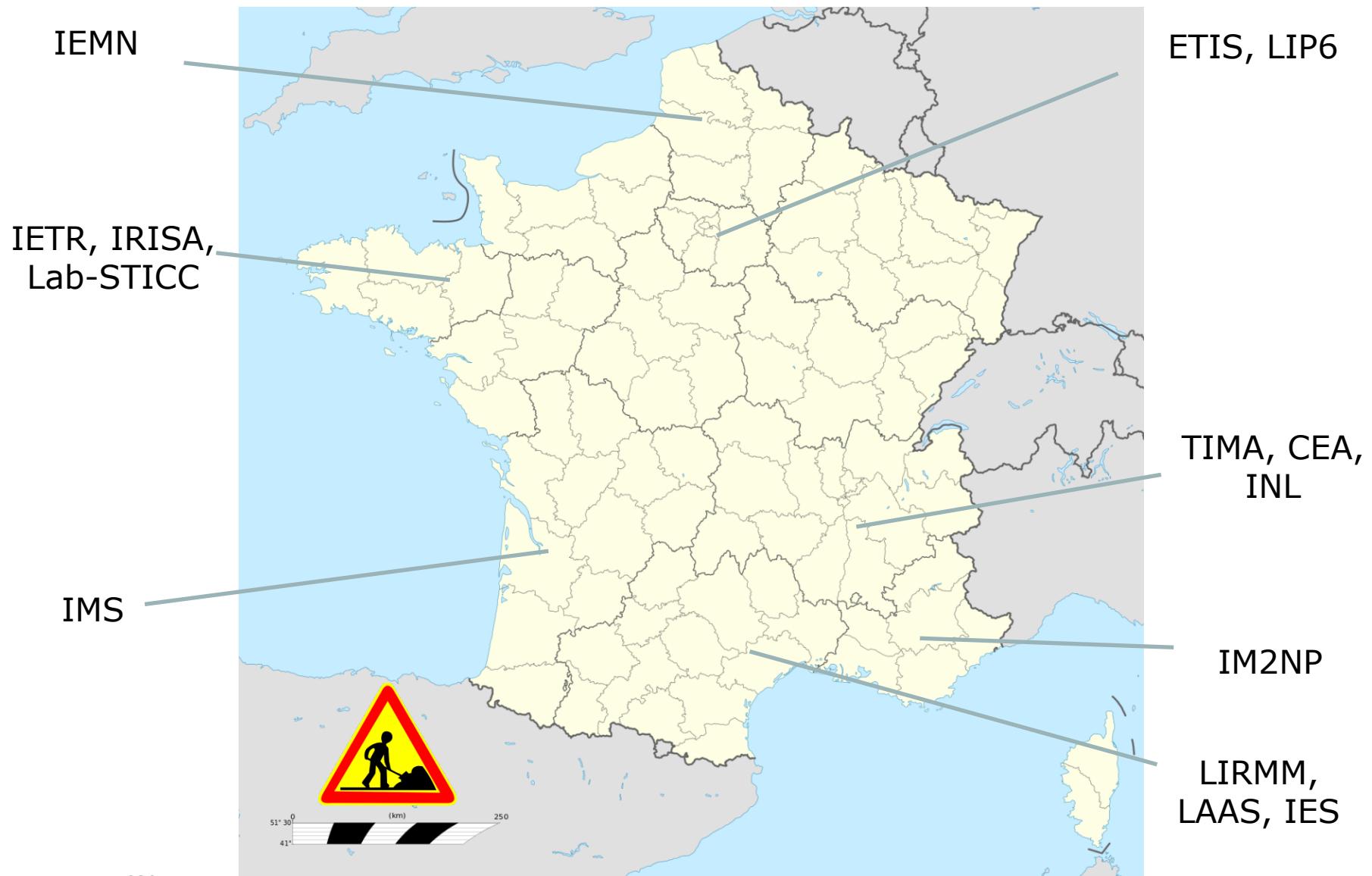
- Mot Clés

- Gestion de l'hétérogénéité et de la complexité
- Support de communication
- Paradigme de calcul

Description de l'axe

- Déploiement
 - Outils et méthodes de conception
- Performances
 - Puissance de calcul, efficacité énergétique, intégration et robustesse (fiabilité et sécurité) des SoC
- Paradigmes de calcul
 - Tirer profit des bonnes propriétés des technologies → paradigmes en rupture: convergences calcul/mémoire, calcul/communication et mémoire/communication
- Applications
 - objets connectés et intégration des SoC sur des substrats non-conventionnels (e.g. électronique souple, plasmonique)

Cartographie

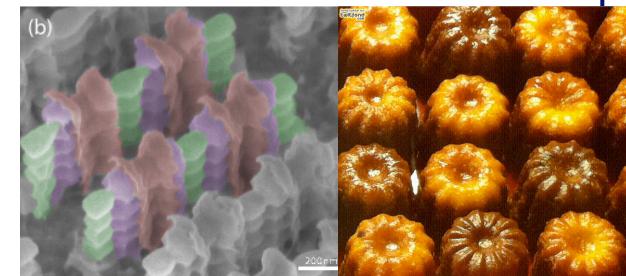


Positionnement au sein du GDR

- Transversal aux axes thématiques
 - Calcul embarqué haute performance : haute performance, efficacité énergétique
 - Frontières et interfaces cyberphysiques : intégration
 - Sécurité et intégrité des systèmes : robustesse
- Lié aux autres axes transversaux
 - Objectés connectés : notion d'usage (bâtiment intelligent, vêtement), lien avec les SHS
 - Méthodes et outils de conception, simulation, évaluation et vérification des systèmes et systèmes de systèmes : extrapolation des performances au niveau circuit et système.

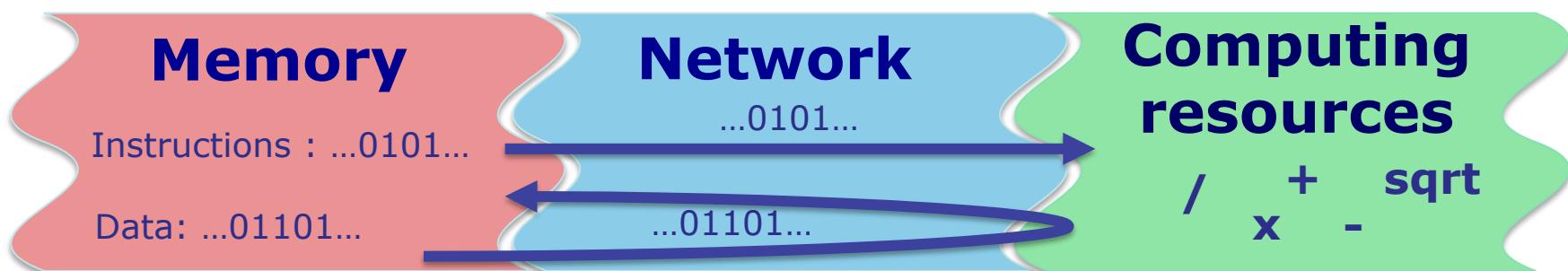
Défis scientifiques

- Performances
 - Fin annoncée de la loi de Moore (7nm en 202₁)
 - Efficacité énergétique des calculs, bandes passantes, etc.
 - 50 GFLOPS/Watt pour atteindre l'exascale
 - Giga-MAC/s/nWatt (MAC = multiply and accumulate operations) à plus long terme
 - 1km à 100 Gb/s
- Méthodes de conception
 - Forte hétérogénéité, difficulté au niveau des interfaces
 - Outils souvent inexistant ou ad hoc
 - Précisions : modèles peuvent reposer sur des extrapolations... d'extrapolations
- Robustesse
 - Contraintes technologiques (expertise requise)
 - Degré de maturité des technologies (évolution plus ou moins rapide)



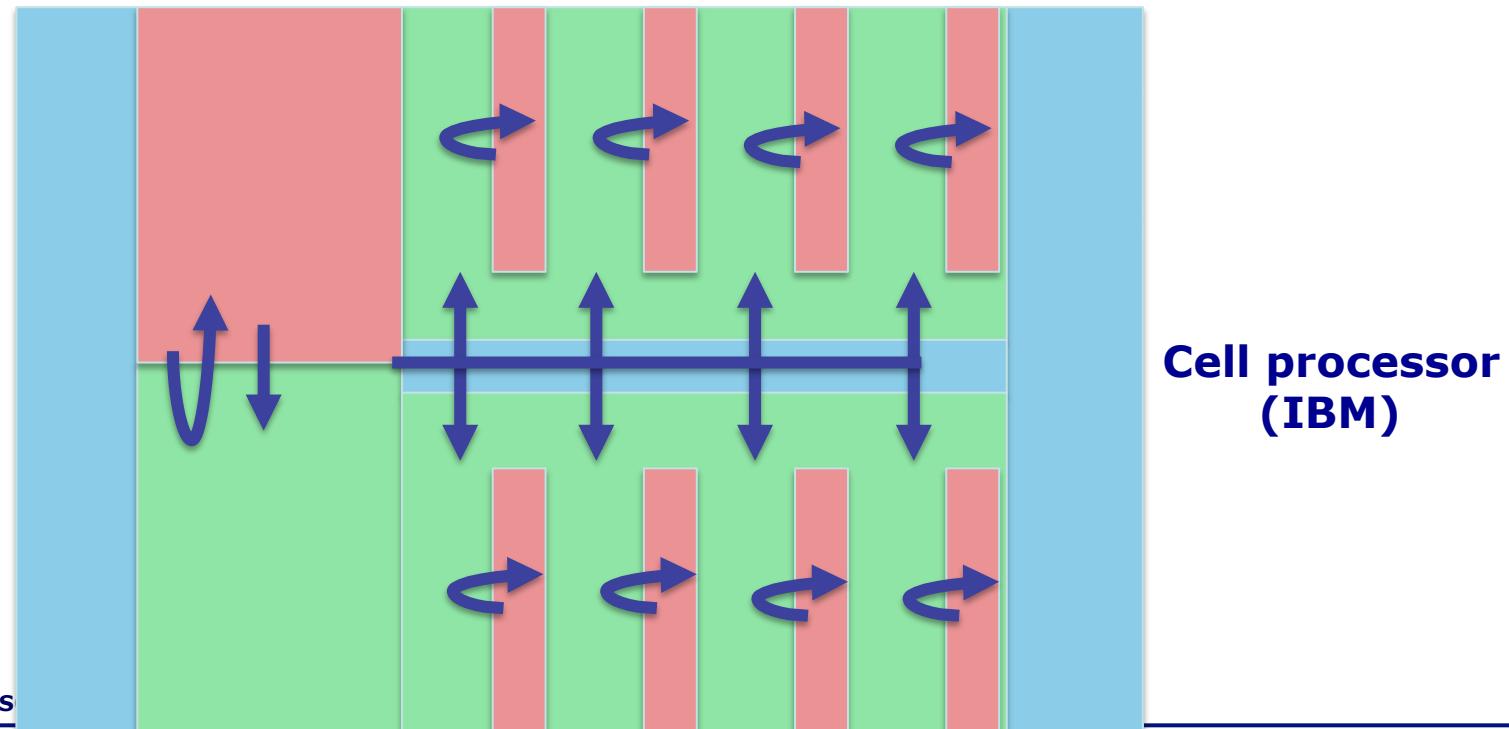
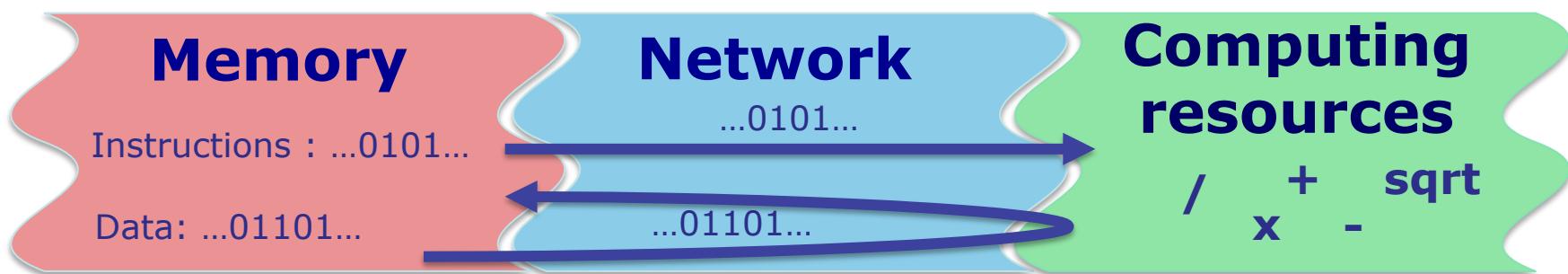
Objectif 1 : Adéquation SoC - technologie

- Mostly Harward like architectures: since 1944



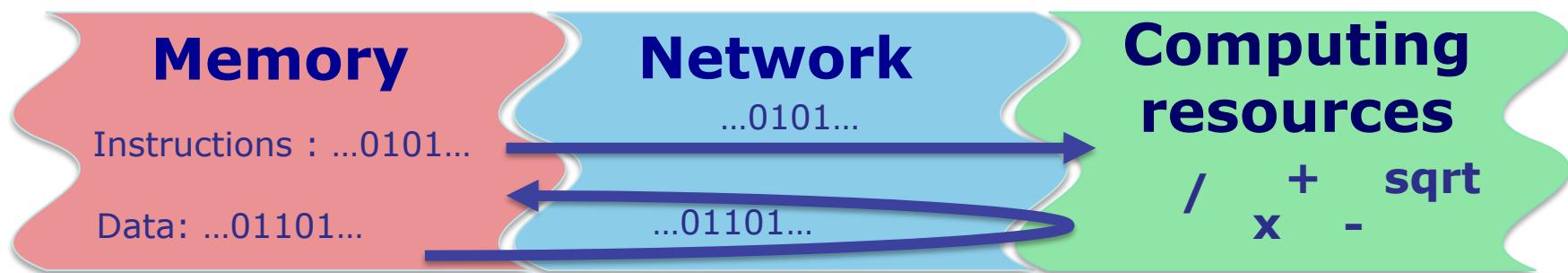
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Datacenters:
100k-1M



Cars:
50-100

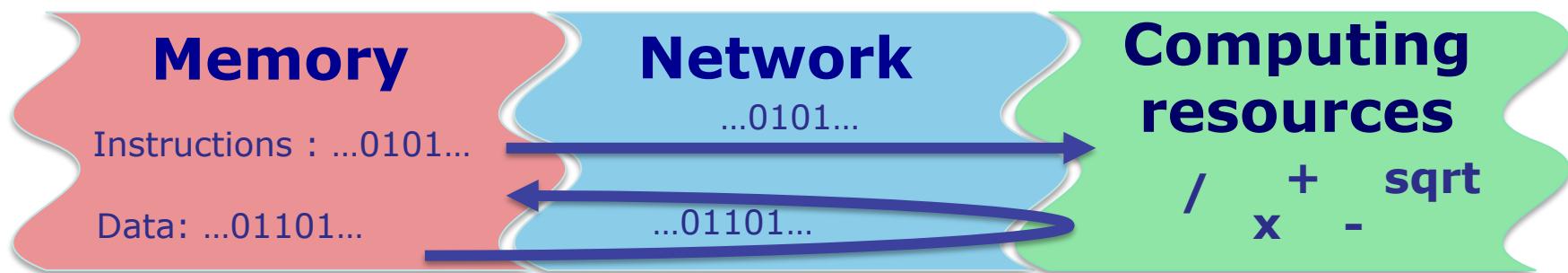


Biomedical:
1-5



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Fault tolerant



High performance

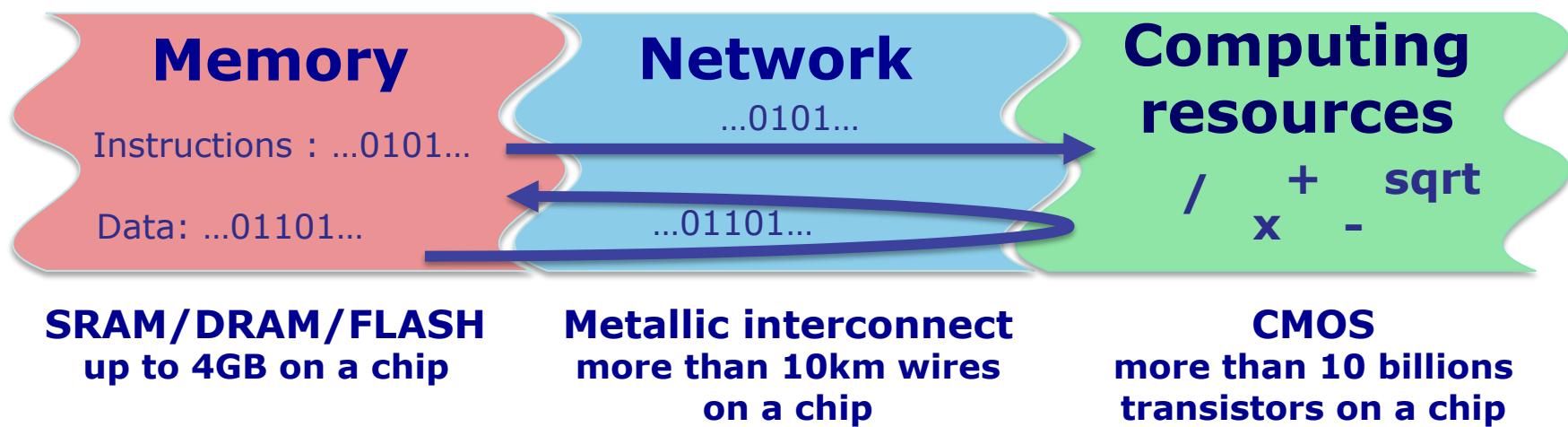


Low power



Objectif 1 : Adéquation SoC - technologie

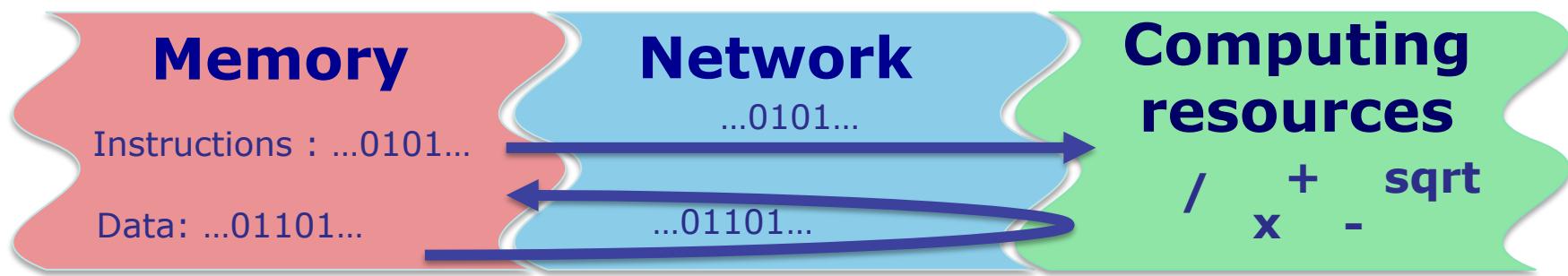
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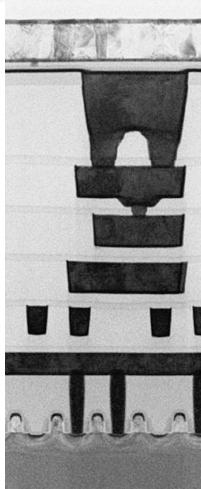
Challenges: higher **performances**, higher **power efficiency**, higher **integration**

Objectif 1 : Adéquation SoC - technologie 1/3

- Mostly Harward like architectures: since 1944



~~SRAM/DRAM/FLASH~~



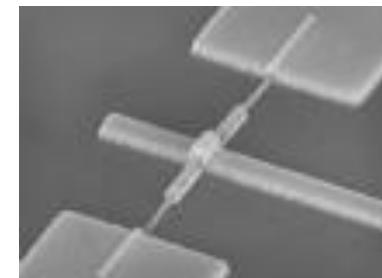
**MRAM, ReRAM,
SeM, etc.**

~~Metallic interconnect~~



**Silicon photonics,
graphene, etc.**

~~CMOS~~

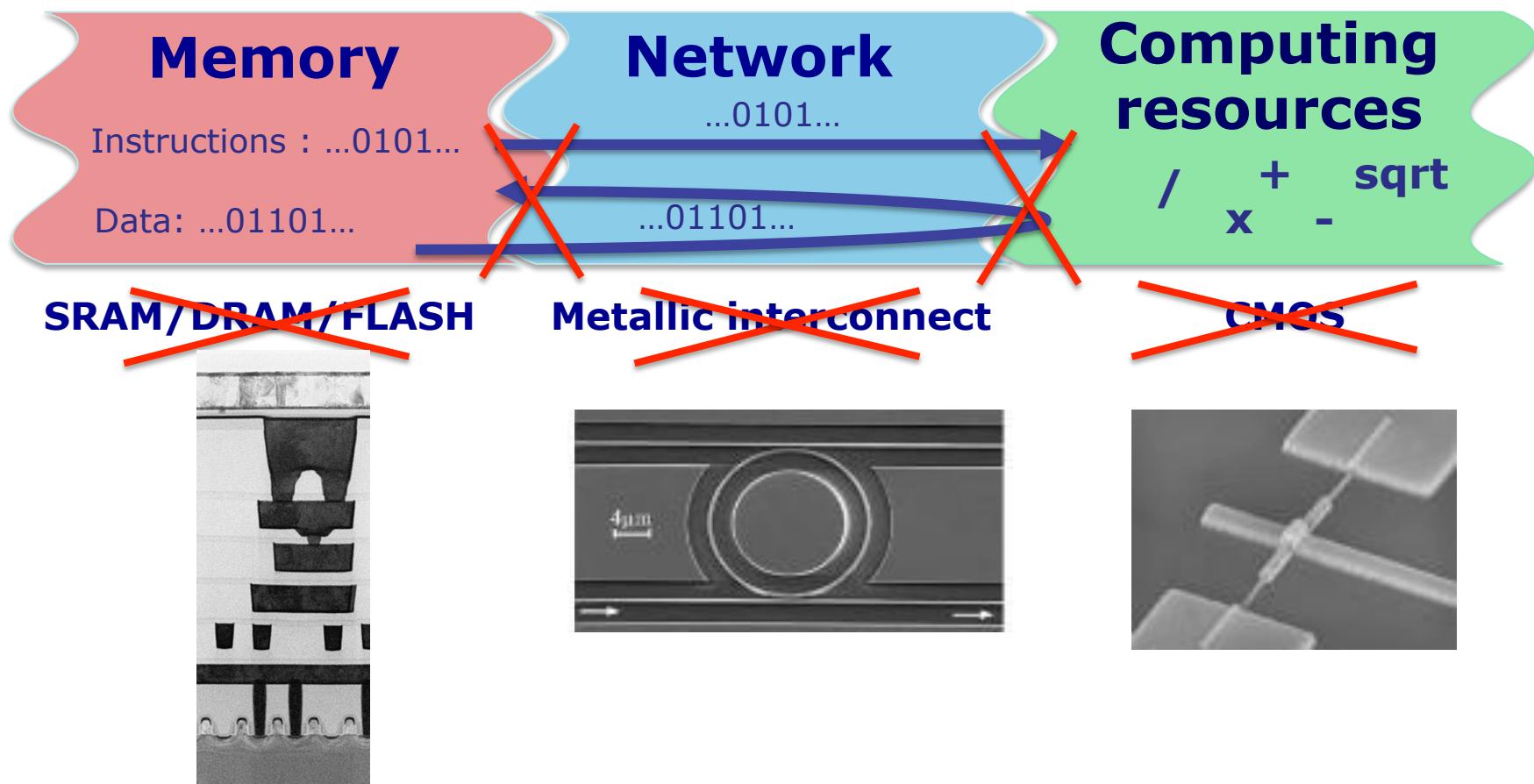


**Nanowire, C-Nanotube,
SeT, molecular, etc.**

Challenges: higher **performances**, higher **power efficiency**, higher **integration**

Objectif 1 : Adéquation SoC - technologie 2/3

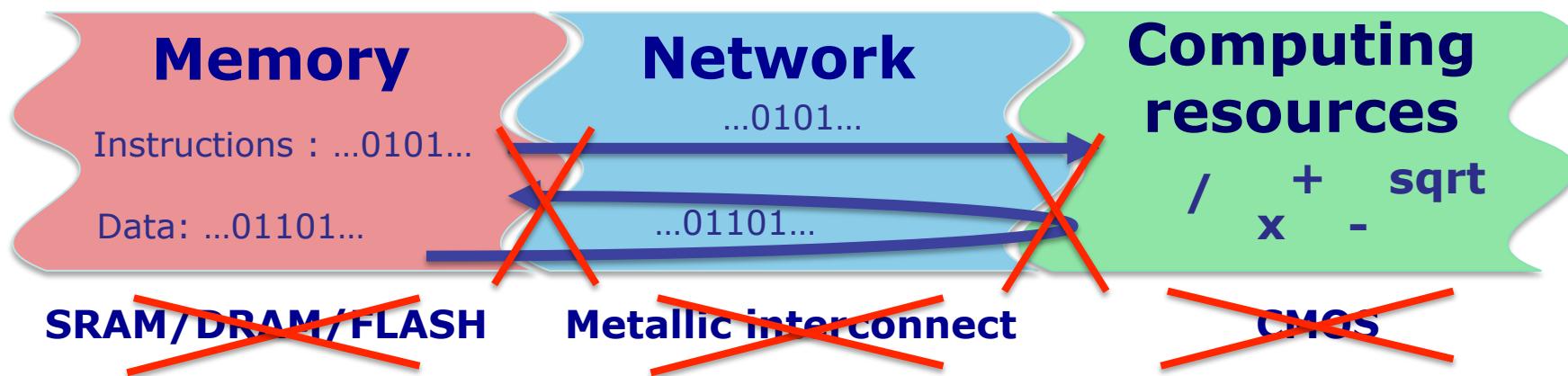
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Challenges: higher **performances**, higher **power efficiency**, higher **integration**

Objectif 1 : Adéquation SoC - technologie 3/3

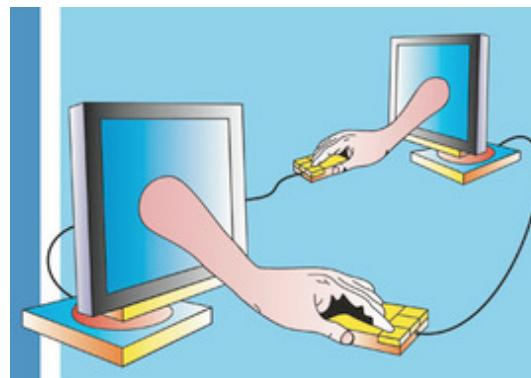
- Mostly ~~Harward~~ like architectures: since 1944



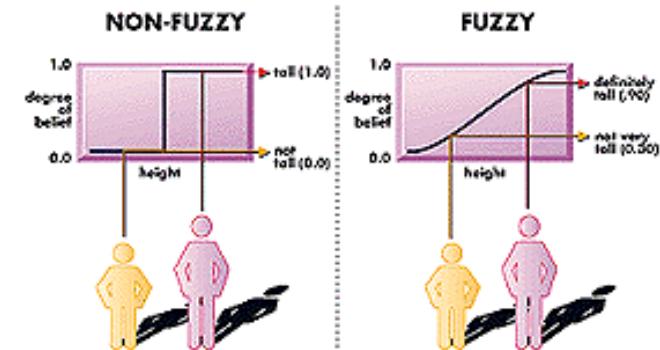
Bio-inspired computing



Reversible computing



Fuzzy logic

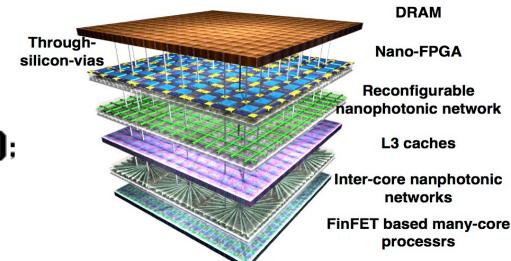


Challenges: higher **performances**, higher **power efficiency**, higher **integration**

Objectif 2 : Homogénéisation des flots de conception

Easily programmable and power efficient processors

```
#INCLUDE <STDIO.H>
INT MAIN()
{
    PRINTF("HELLO, WORLD !");
    RETURN 0;
}
```



Key enabler:
Design methodologies

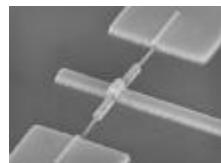
- 1-models
- 2-simulations
- 3-exploration



Bottom-up
Top-down



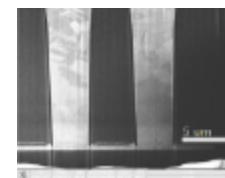
Key enabler:
Emerging technologies



DGFET



Silicon photonics



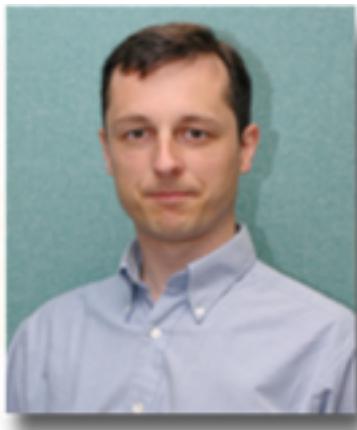
3D

Challenges: higher **performances**, higher **power efficiency**, higher **integration**

Actions 2017/2018

- Journée interconnexions
 - En relation avec l'axe « *Calcul embarqué haute performance* »
 - Impact des technologies de communications émergentes sur les architectures (ONoC, WNoC, etc.)
 - Automne 2017
- BarCamp mémoires émergentes
 - En relation avec les axes « *Calcul embarqué haute performance* » et « *Sécurité et intégrité des systèmes* »
 - Impact des mémoires émergentes sur les architectures et les paradigmes de calcul
 - Printemps 2018

Présentation



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Applications des technologies photoniques pour l'accès aux domaines de fréquence THz

Science and technologies based on terahertz frequency electromagnetic radiation (100 GHz–30 THz) have developed rapidly over the last 30 years. For most of the 20th Century, terahertz radiation, then referred to as sub-millimeter wave or far-infrared radiation, was mainly utilized by astronomers and some spectroscopists. Following the development of laser based terahertz time-domain spectroscopy in the 1980s and 1990s the field of THz science and technology expanded rapidly, to the extent that it now touches many areas from fundamental science to 'real world' applications. For example THz radiation is being used to optimize materials for new solar cells, and may also be a key technology for the next generation of airport security scanners. While the field was emerging it was possible to keep track of all new developments, however now the field has grown so much that it is increasingly difficult to follow the diverse range of new discoveries and applications that are appearing. At this point in time, when the field of THz science and technology is moving from an emerging to a more established and interdisciplinary field, it is apt to present a roadmap to help identify the breadth and future directions of the field. The aim of this roadmap is to present a snapshot of the present state of THz science and technology in 2017, and provide an opinion on the challenges and opportunities that the future holds.