Perspective of Collaborative research in future Computing systems between Europe and India

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Major Thrust in future Research

- Computing system is pervasive in every day life
- Complexity of computing system is increasing
  - Constraints of frequency, level of silicon integration, interconnection across the modules, Optimisation of SW tasks in sharing the processor power, energy consumption, processing power/supercomputing for scientific work, cloud computing, security etc…
- Need of adapating the system architecture for reconfiguration, optimised process, multi- and many-core processing with appropriate SW task sharing
- Tuning of computing system for specific application areas
- Man-machine cognitivity for higher performance: user interfaces and conception

Ubiquity in computing and Communication

Meeting the contraints:

- VLSI density
- Frequency
- Parallelisation
- Energy consumption
- Number of cores
- Task sharing
- Performance

Challenges lie both in Hardware and Software development with International collaboration

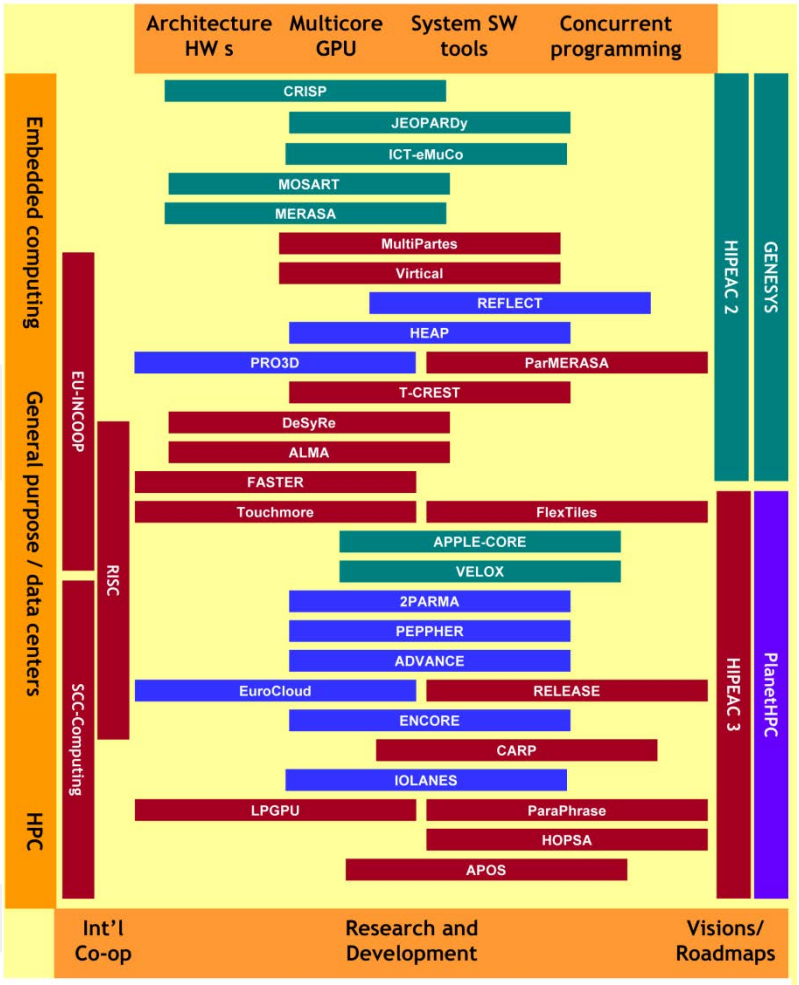
Next Generation Computing system Challenges

- operating systems, computer architecture, and their interaction
- System modelling and analysis
- distributed, parallel, and cloud systems
- networking, mobile, wireless, peer-to-peer, and sensor systems
- runtime systems and compiler/programming-languages support
- energy/power management
- file and storage systems
- security, privacy, and trust
- virtualization
- embedded and realtime systems
- fault tolerance, reliability, and availability
- deployment, usage, and experience
- performance evaluation and workload characterization

European FP7 activities

There are number of running projects addressing multiple issues of Computing Systems research covering;

- Architecture and Hardware
- Multicore and GPU
- System Software and Tools
- Concurrent Programming



Key challenges to be addressed

- Computer design and architecture
- Storage technologies database systems, and data management
- Operating systems, middleware, and distributed systems
- Computer graphics and visualization
- Supercomputing

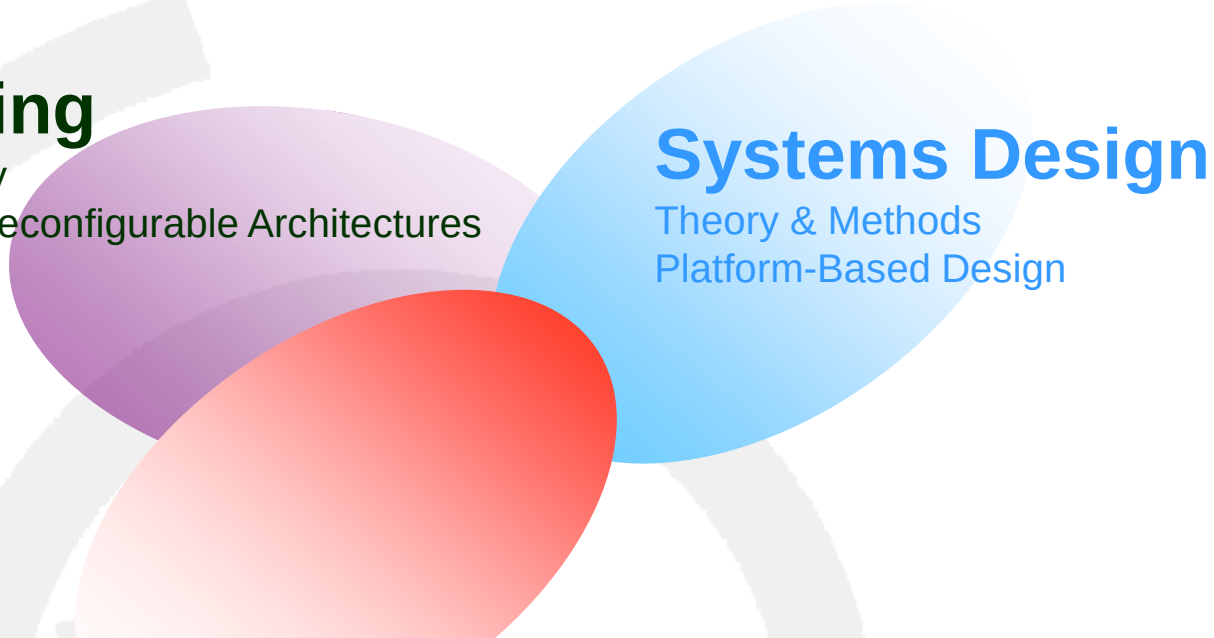
Computer System design and architecture

- Core technology will be based on Silicon
- Main challenges include:
  - power dissipation, low-power, power management, modeling and simulation of high-frequency circuits (5-40GHz) and nanometer structures, design-implementation productivity, design reuse, design integration and test as well as yield enhancement.
  - Intra-chip communication and synchronization with distributed and parallel designs to improve the latency
  - Reconfigurable computing for error tolerance, adaptiveness, automated design, distributed architectures, massive parallelism etc.
  - Better Evaluation Methods and Tools to master the complexity and to improve the performance

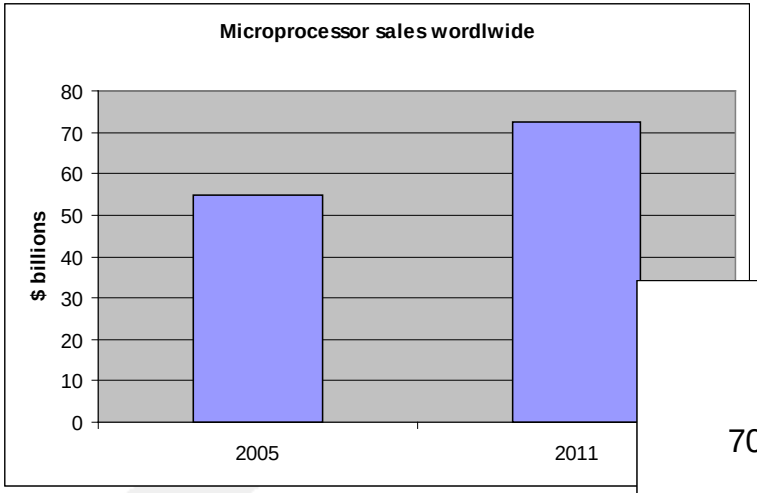
European Vision activities

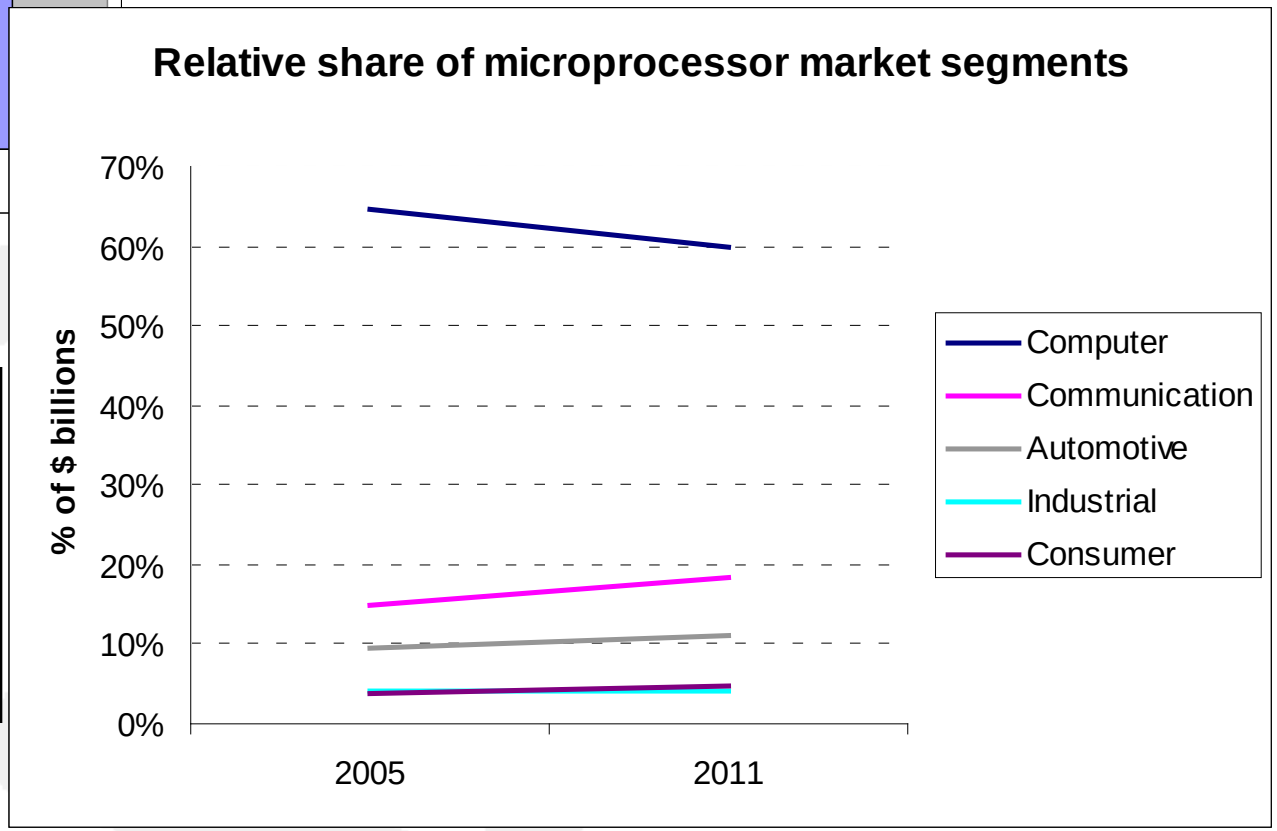
- European Technology platforms (ETPs)
  - ARTEMIS: ***A****dvanced* ***R****esearch &****T****echnology for* ***Em****bedded* ***I****ntelligence and* ***S****ystems*
    - www.artemis.eu
  - NESSI: *Networked European Software and Services Initiative*
    - www.nessi-europe.com
- Network of Excellence
  - HIPEAC
    - www.hipec.net
- Support Project
  - PlanetHIPC
    - www.planethpc.eu

Main themes of ongoing Research



Market dynamics

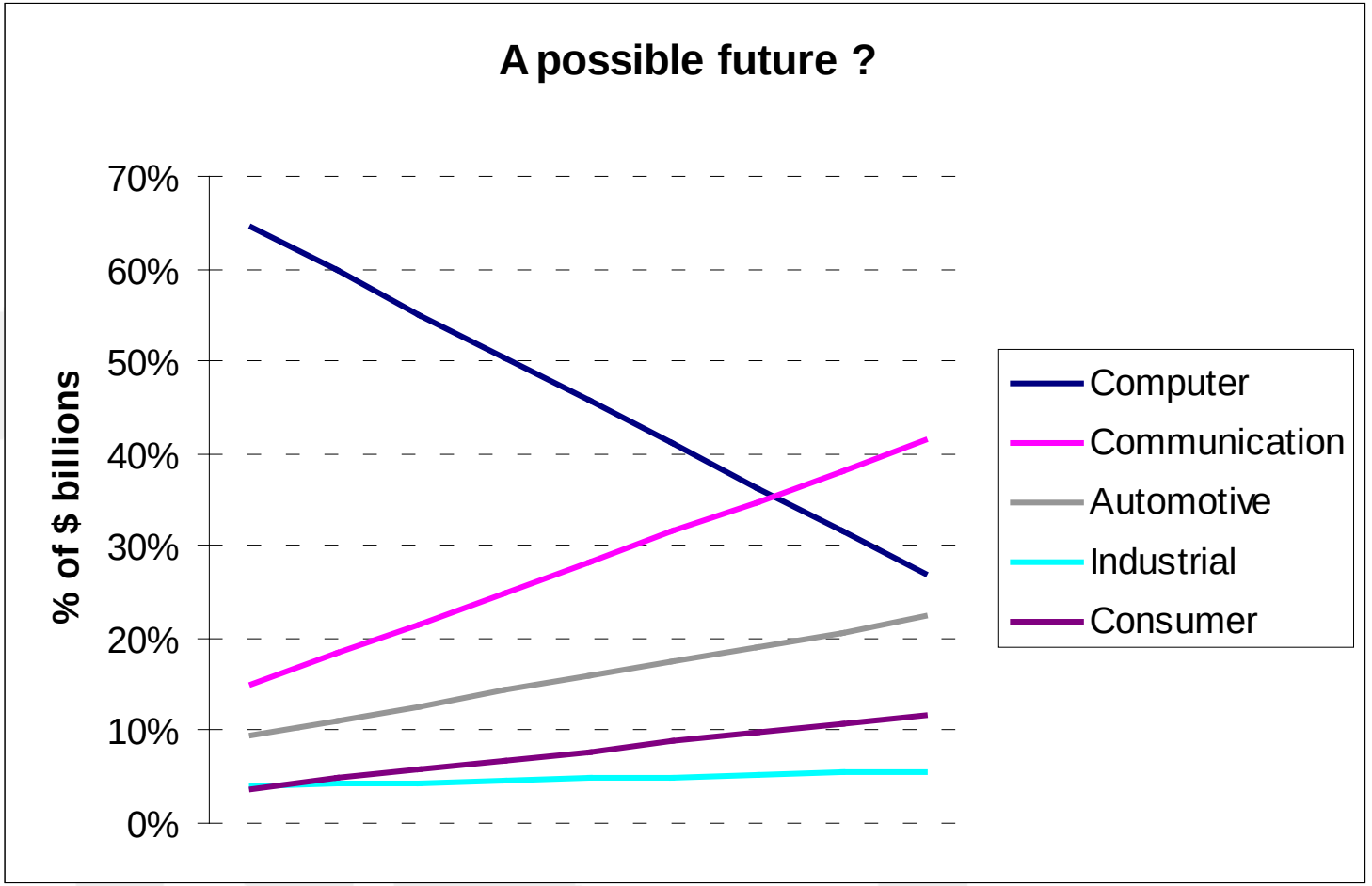




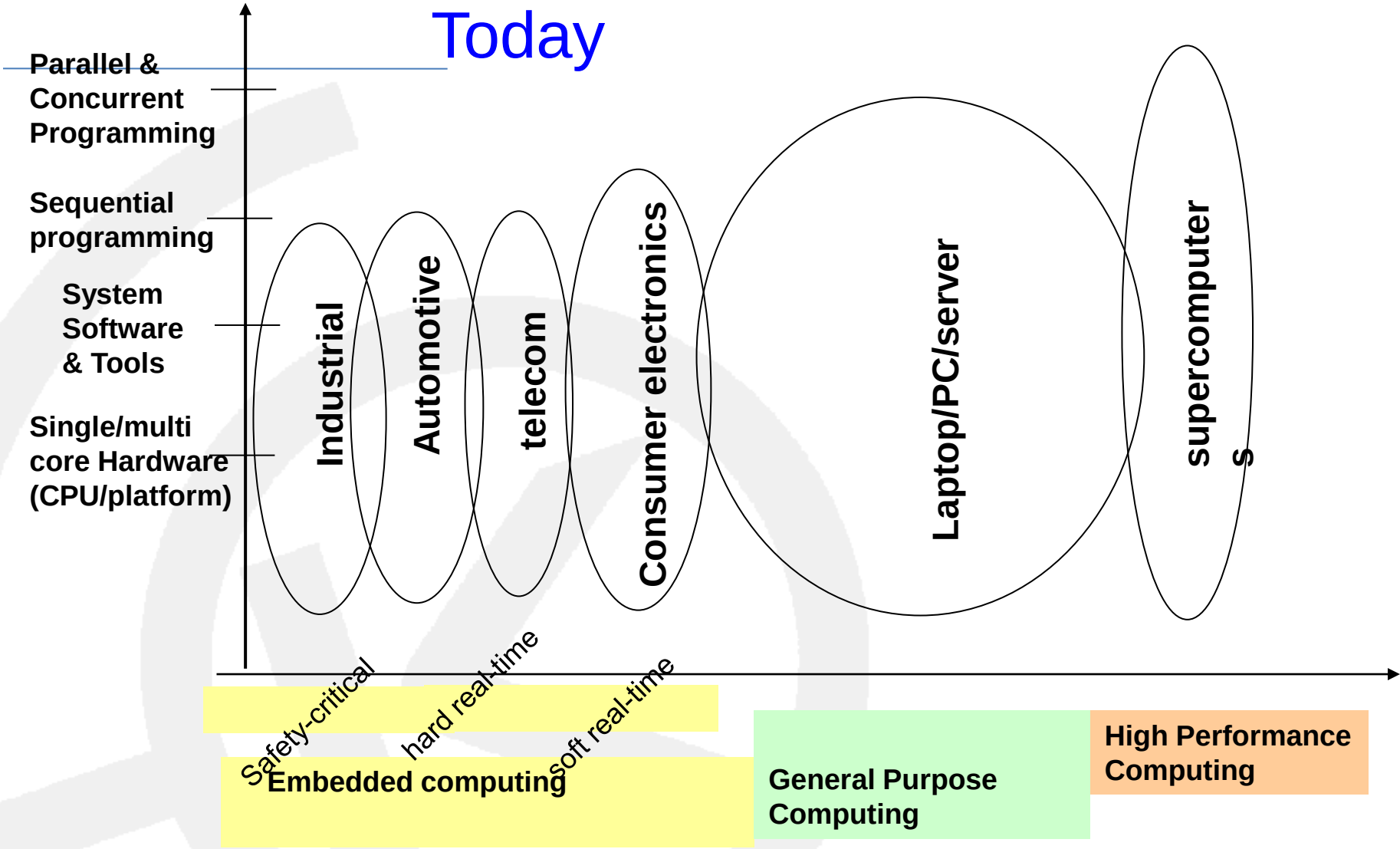
- Sales of microprocessors are projected to increase
- The share of the *computer* market segment will decline
- Shares of other market segments will increase

Source:InStat

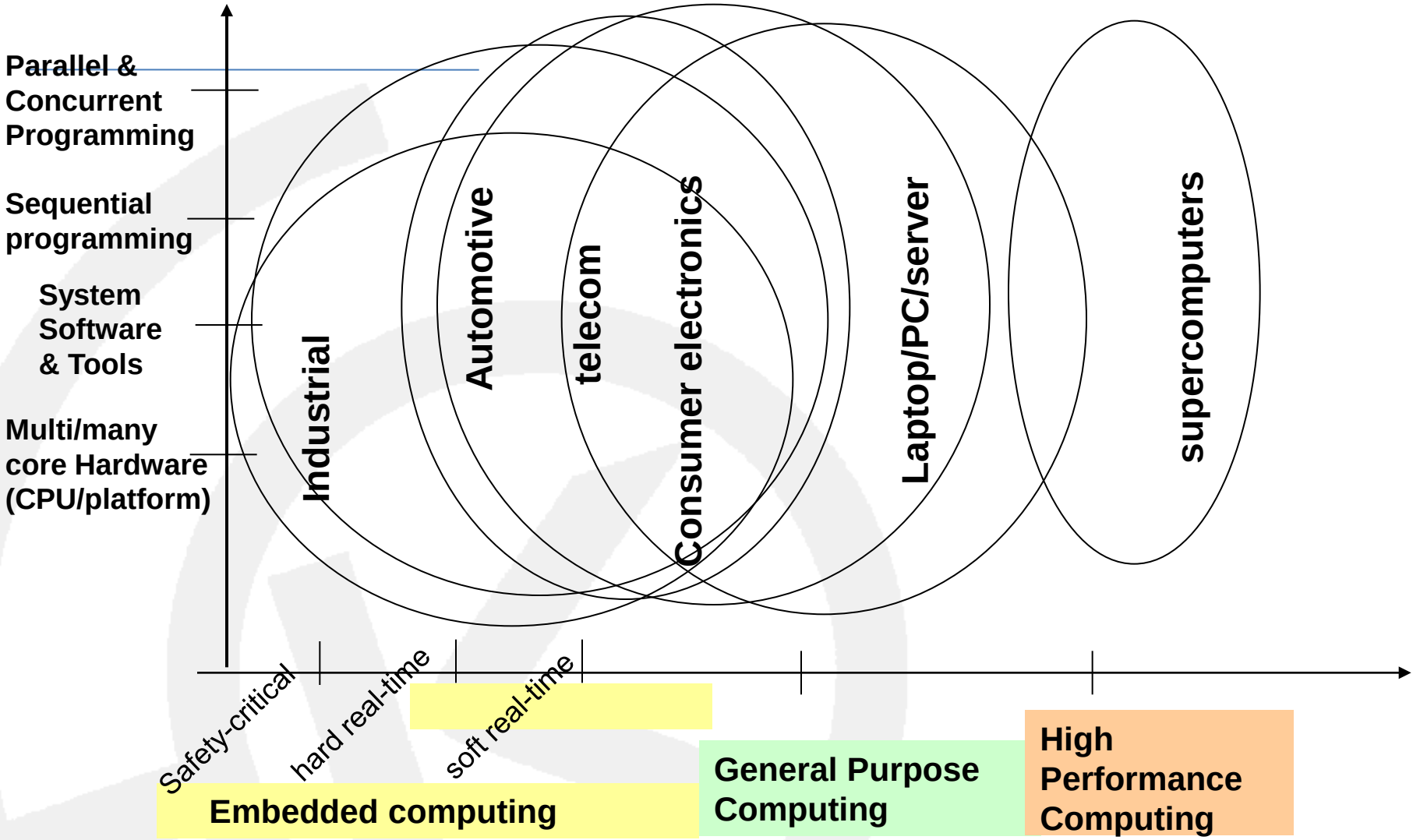
Long-term market dynamics



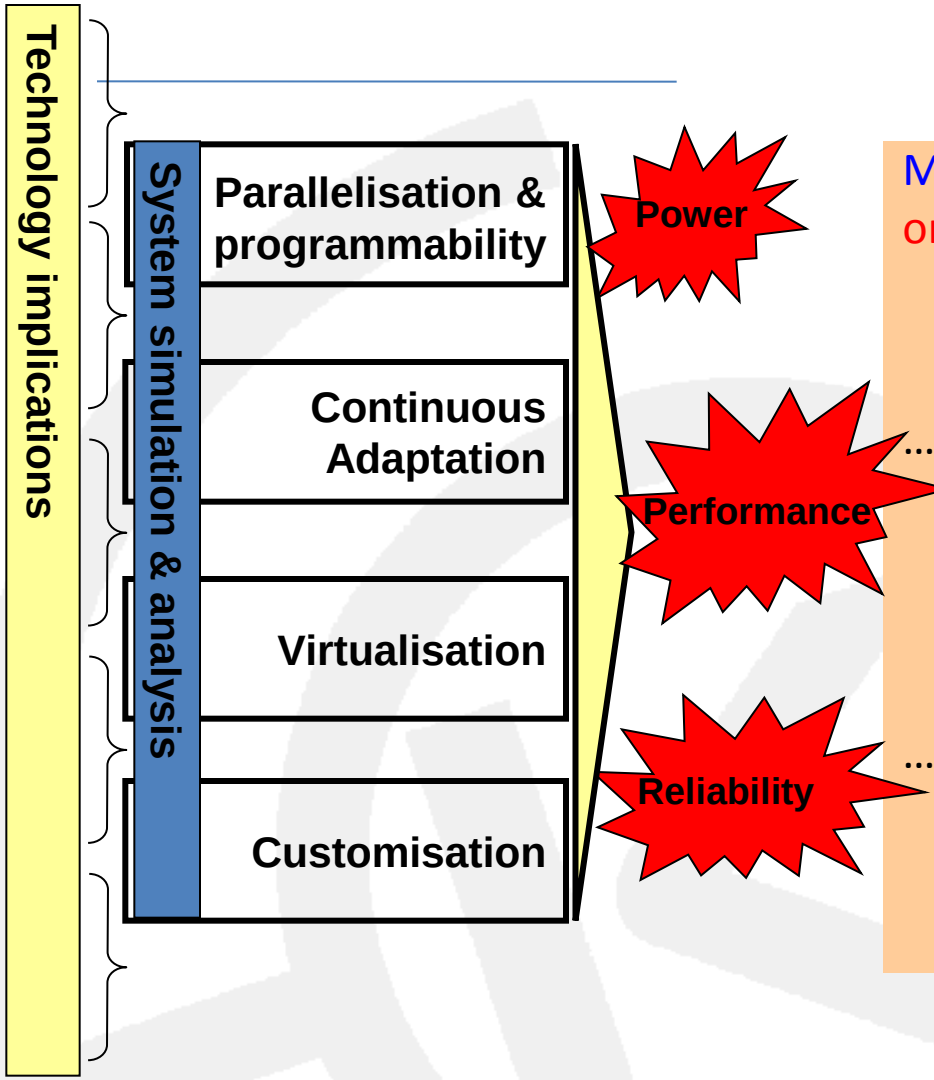
Computing is facing a radical change



Main spheres of application



System of Systems



Multicore and/or reconfigurable on-chip computing systems must offer …

- *More **performance***
- *More **power-efficiency***
- *More **reliability***

… through breakthroughs in …

- ***Parallelisation & Programmability***
- ***Continuous Adaptation***
- ***Customisation***
- ***Virtualisation***
- ***System simulation and analysis***

… without forgetting …

- ***technology implications***
  e.g. ***3D stacking***

Parallelisation & Programmability

- Automatic parallelisation, new high-level parallel programming languages and/or extensions to existing languages taking into consideration that user uptake is a crucial issue.
- Projects on programmability & parallelism of multi-core and/or reconfigurable architectures should adopt a holistic approach addressing issues related to the underlying hardware and to the system software.
- Research areas include
  - beyond static auto-parallelisation by exploiting dynamic (run-time) information;
  - new support environments including testing, verification and debugging, program & performance monitoring and analysis;
  - specific hardware support for parallel programming models.

Methodologies, techniques and tools

- **Continuous Adaptation:** Multicore and/or reconfigurable systems that continuously adapt to a constantly changing environment by going beyond the strict separation between compiler, runtime and hardware.

- **Virtualisation** technologies that ensure portability, flexibility, optimised use of resources and overcome legacy issues for multicore and/or reconfigurable systems. This includes hardware/software interfaces for efficient virtualisation as well as machine abstractions and performance models for virtualised homogeneous or heterogeneous systems.

- **Customisation:** Rapid extension and/or configuration of existing systems, architectural templates and tool-chains to optimally address specific application needs and performance/Watt envelopes.

System simulation and analysis

- **System simulation and analysis:** Advanced simulation and analysis of complex multicore systems to drastically improve the simulation speed of new complex, homogeneous or heterogeneous, multi-core systems

Technology implications

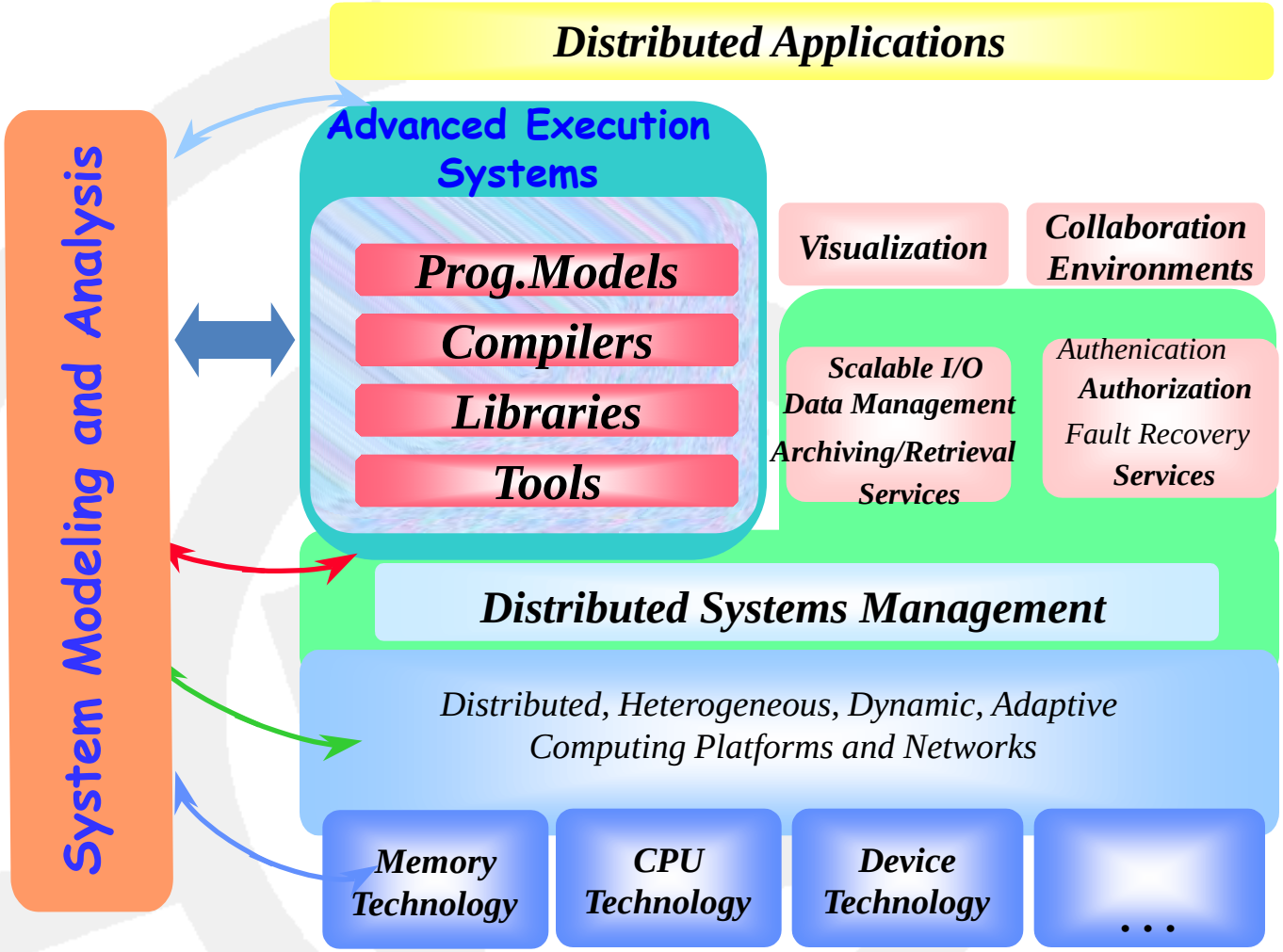
- Advanced system architectures, tools and compilers for next-generation semiconductor fabrication technology
- The key challenge is to bridge architecture, system and technology research efforts

International collaboration in High Performance Computing

- Initiatives to align research agendas and coordinate R&D activities in high performance computing in order to advance the Research Activities; taking into account industrial and academic activities and programmes at regional, national and international supercomputing roadmaps.
- **EUINCOOP** is one such project trying to identify common research agenda between India and Europe.

  (www.euincoop.eu)

View of Computing System challenges



System Modeling and Analysis (SMA)

Seeks to develop methods and tools for modeling, measuring, analyzing, evaluating, and predicting the performance and correctness of complex computing and communications systems

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Topics of Interest

- Hardware and Software modeling
  - methods tools and measurements, providing multimodal, hierarchical or multilevel modeling and analysis capabilities of such systems;
  - methods that describe components of the system, but also the system as a total, and enable assessment of the effects of individual hardware and software layers and components of these systems;
  - ability to describe the system in multiple levels of detail (characteristics and time-scales);
  - combine different methods of describing components and layers

System Modeling and Analysis (SMA)

Topics of Interest (cont'd)

- Novel modeling and measurement approaches
  - Develop capabilities to describe, analyze and predict the behavior of the components as well as the systems; Analysis and prediction due to changes in the application, system software, hardware; multilevel approaches and multi-modal approaches
- Performance Frameworks
  - combine tools in "plug-and-play" fashion
  - multiple views of the system

Emphasis on Multidisciplinary Research (across sub-areas of CS)

System Modelling and Analysis

- Novel modeling and measurement approaches
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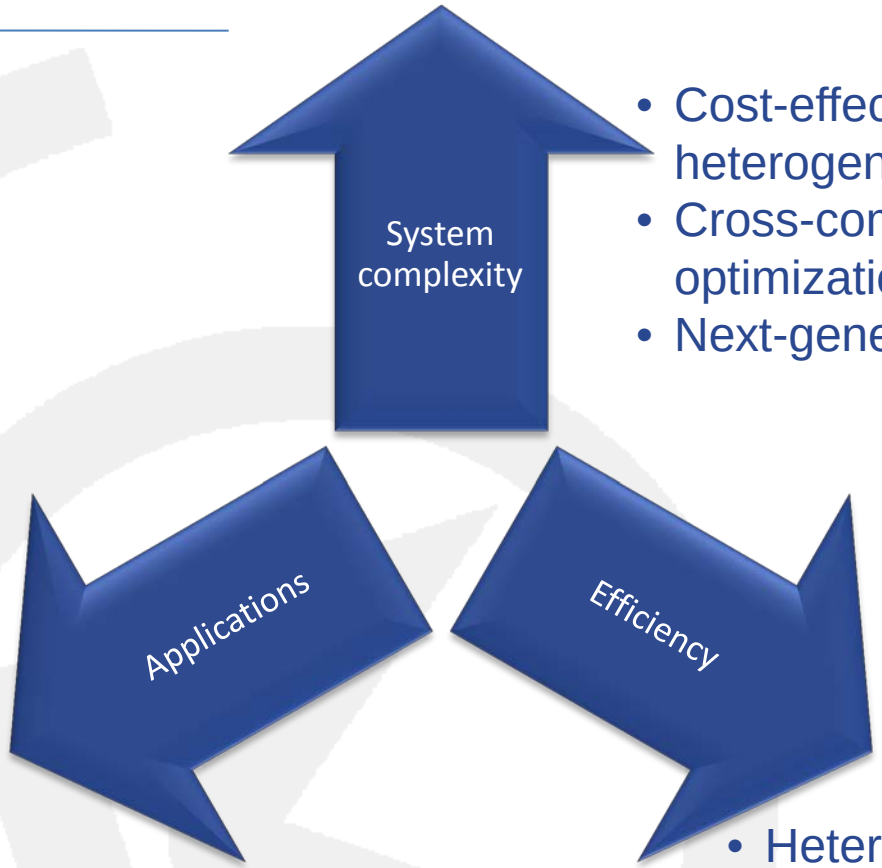
Advanced Execution System

- Programming models and tools
  - expressing application partitioning across distributed, heterogeneous computing platforms; application-level checkpointing and recovery
- Application composition system (ACS) technology
  - constructing applications to fit the available resources and to adapt to changes in the underlying execution environment;
  - methods for automatically selecting application components;
  - creating knowledge bases for application components; interfacing with the underlying computing platform models to determine suitable application components;
  - and developing appropriate application component libraries and interfaces so the run-time portion of the RCS can link to such libraries.

HiPEAC Research Challenges



- Cost-effective software for heterogeneous multi-cores
- Cross-component/cross-layer optimization for design integration
- Next-generation processor cores

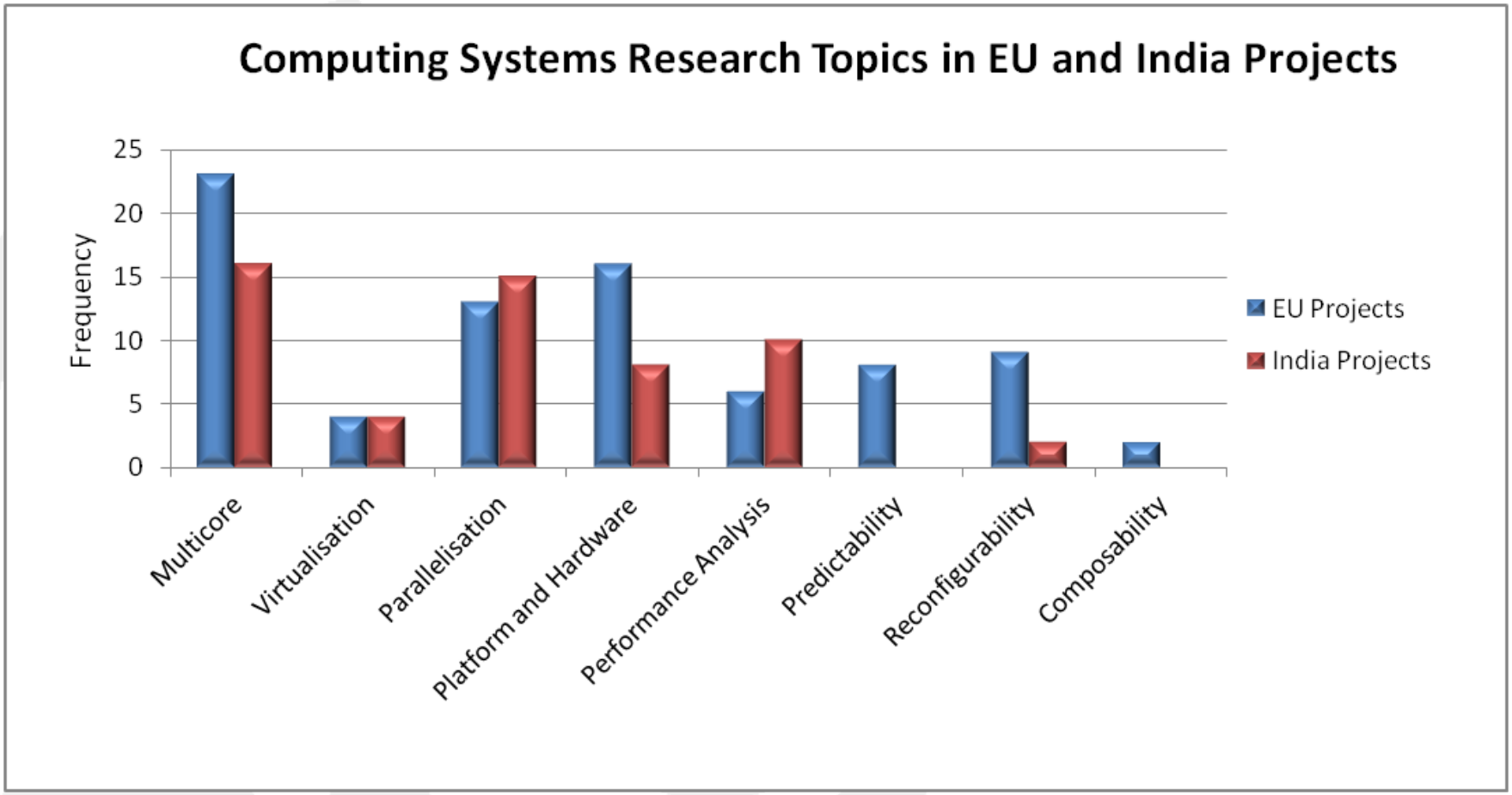
- Architectures for the Data Deluge
- Reliable systems for Ubiquitous Computing

- Heterogeneous computing systems
- Locality and communications management

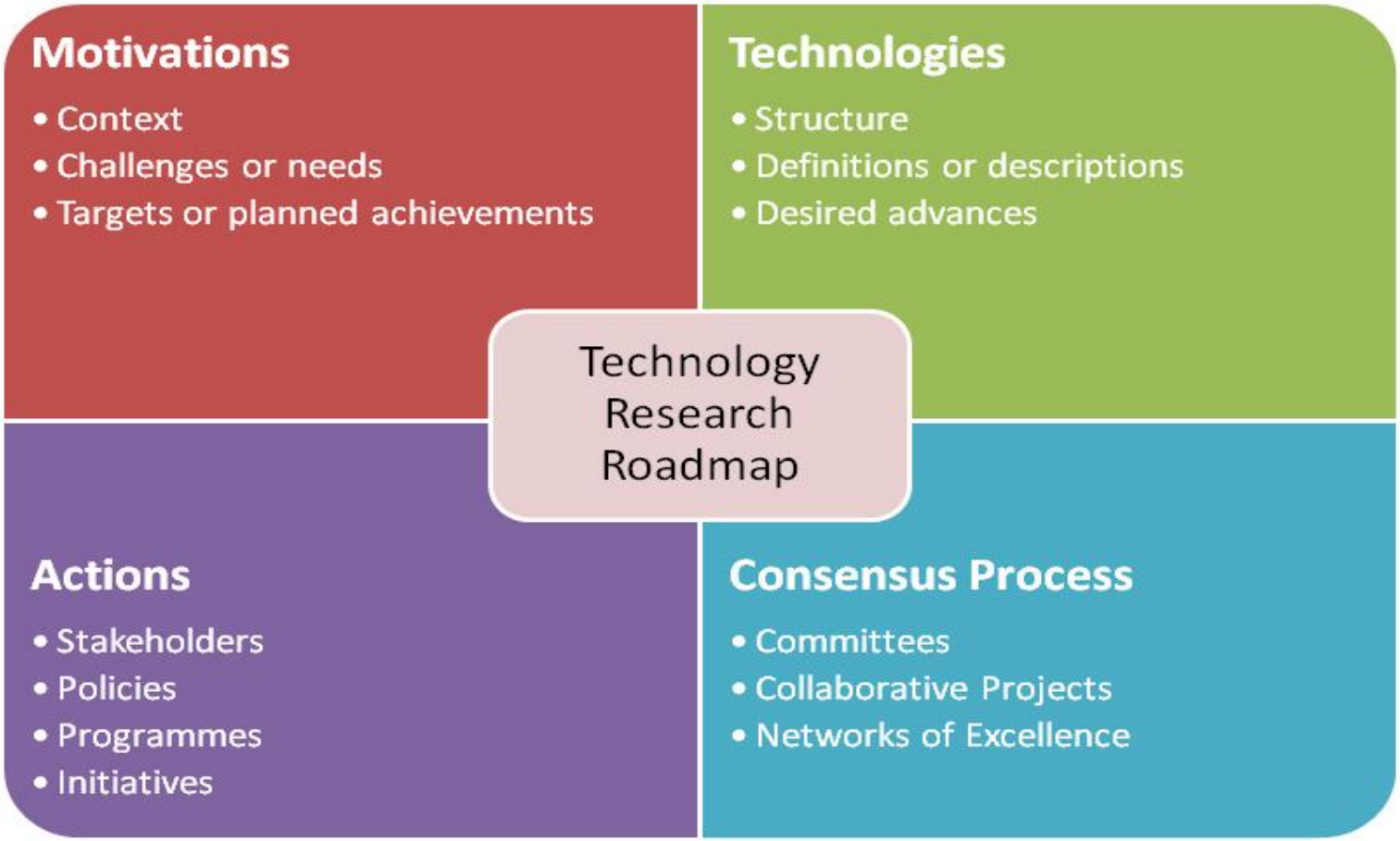
Technology areas for cooperation

- Multicore
- Virtualisation
- Parallelisation
- Platform and Hardware
- Performance Analysis
- Predictability
- Reconfigurability
- Composability

EURO-INDIA Co-operation opportunities

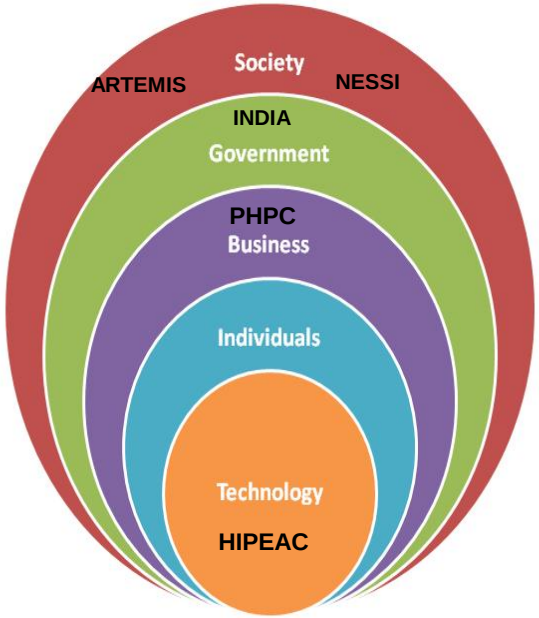


Joint Roadmap activities



Motivation levels for Technology Roadmap

India: Contribute to overall socio-economic growth, Promote R&D for development, commercialisation and manufacturing of products, packages and services, Widen the R&D base in the country, and expand R&D infrastructure, Innovation promotion and development of entrepreneurs



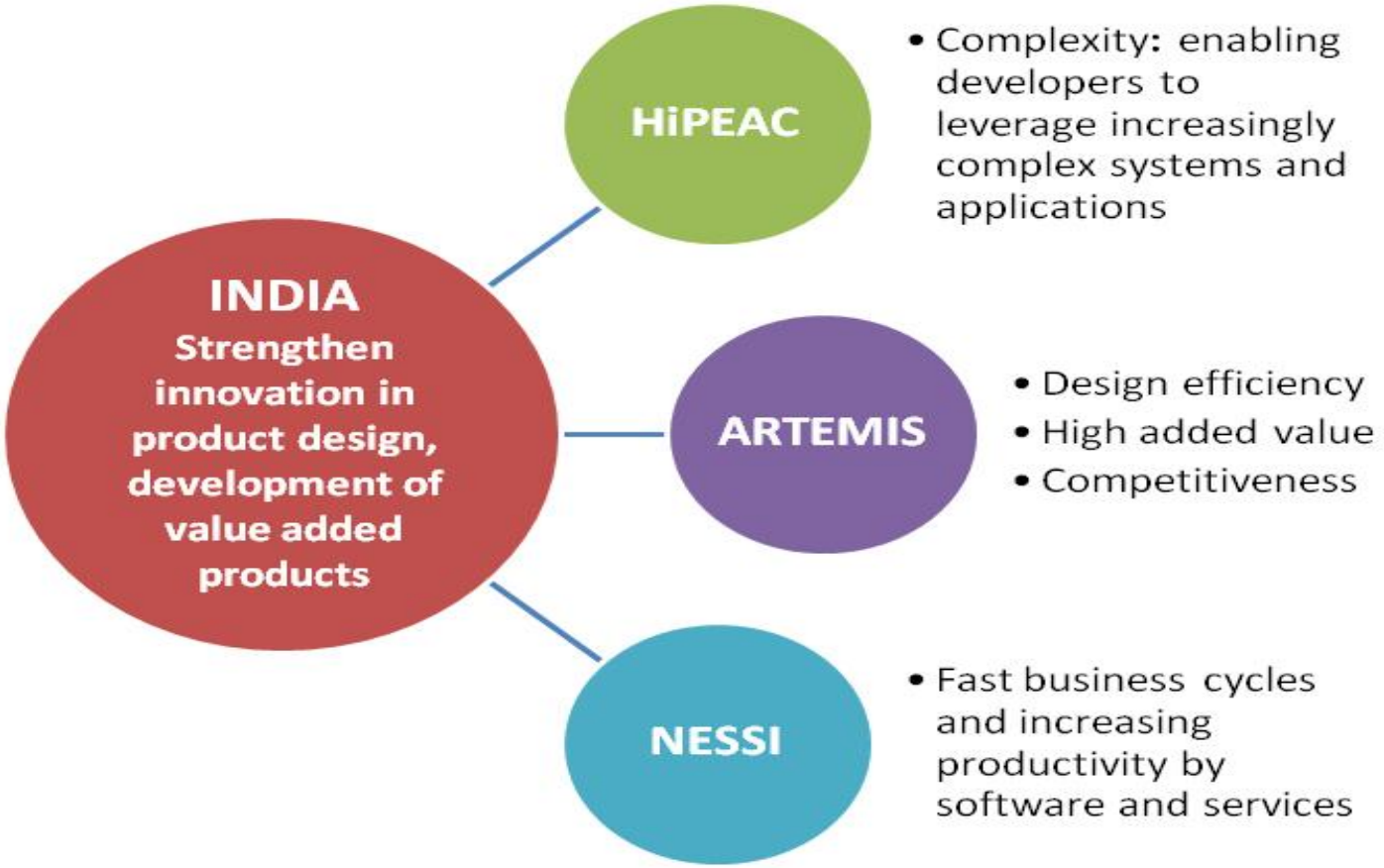
HIPEAC: Complexity arising from multicore, Power efficiency for platforms, Increasing data volumes Heterogeneous systems

PHPC: Scalability to support many-core platforms, Accessibility of HPC technology for business, Usability for building applications, Migratability of HPC to new platforms

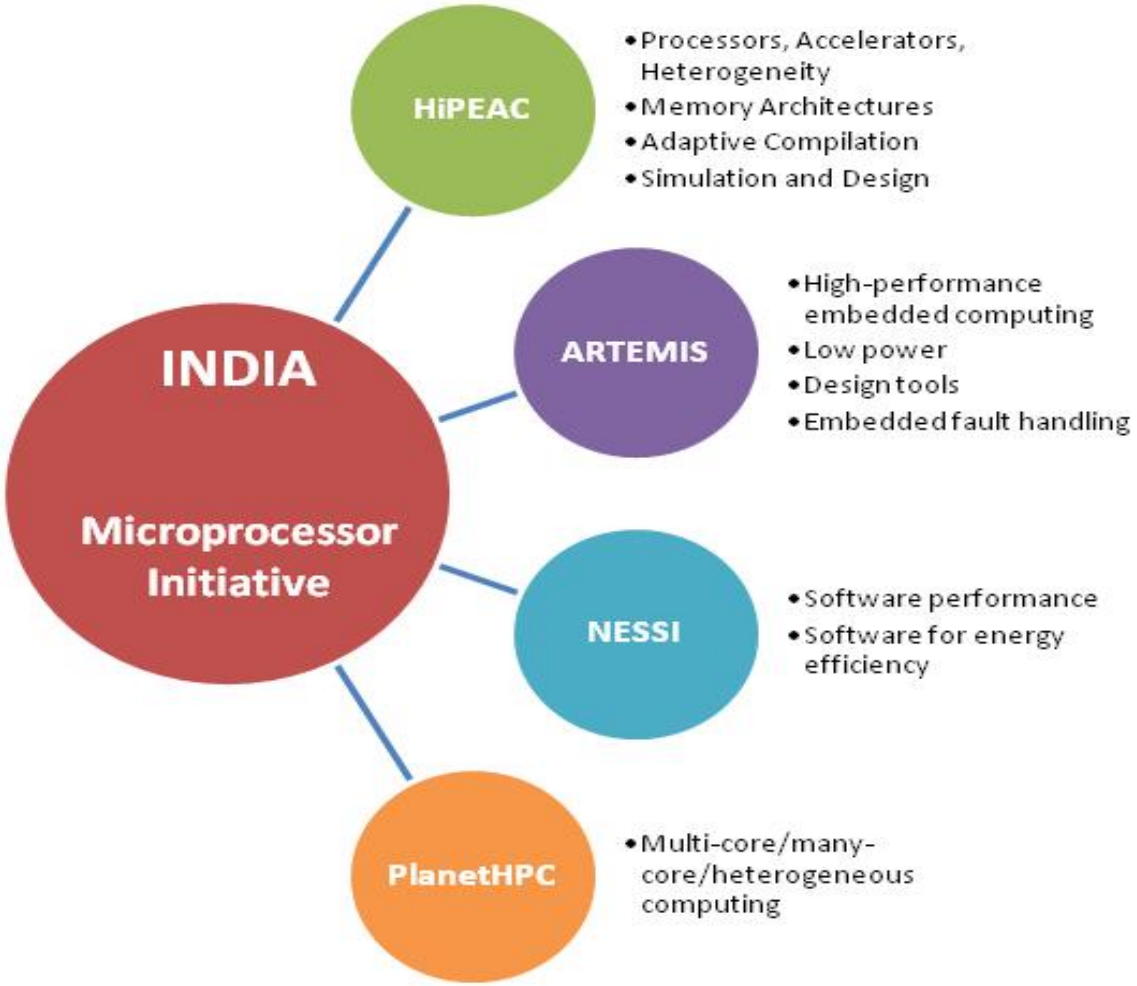
ARTEMIS: Affordable Healthcare and Wellbeing ; Green, safe, and supportive transportation, Smart buildings and communities of the future

NESSI: Sustainable economic and social benefits, Lack of interoperability, Fragmented digital markets, Rising cybercrime and risk of low trust

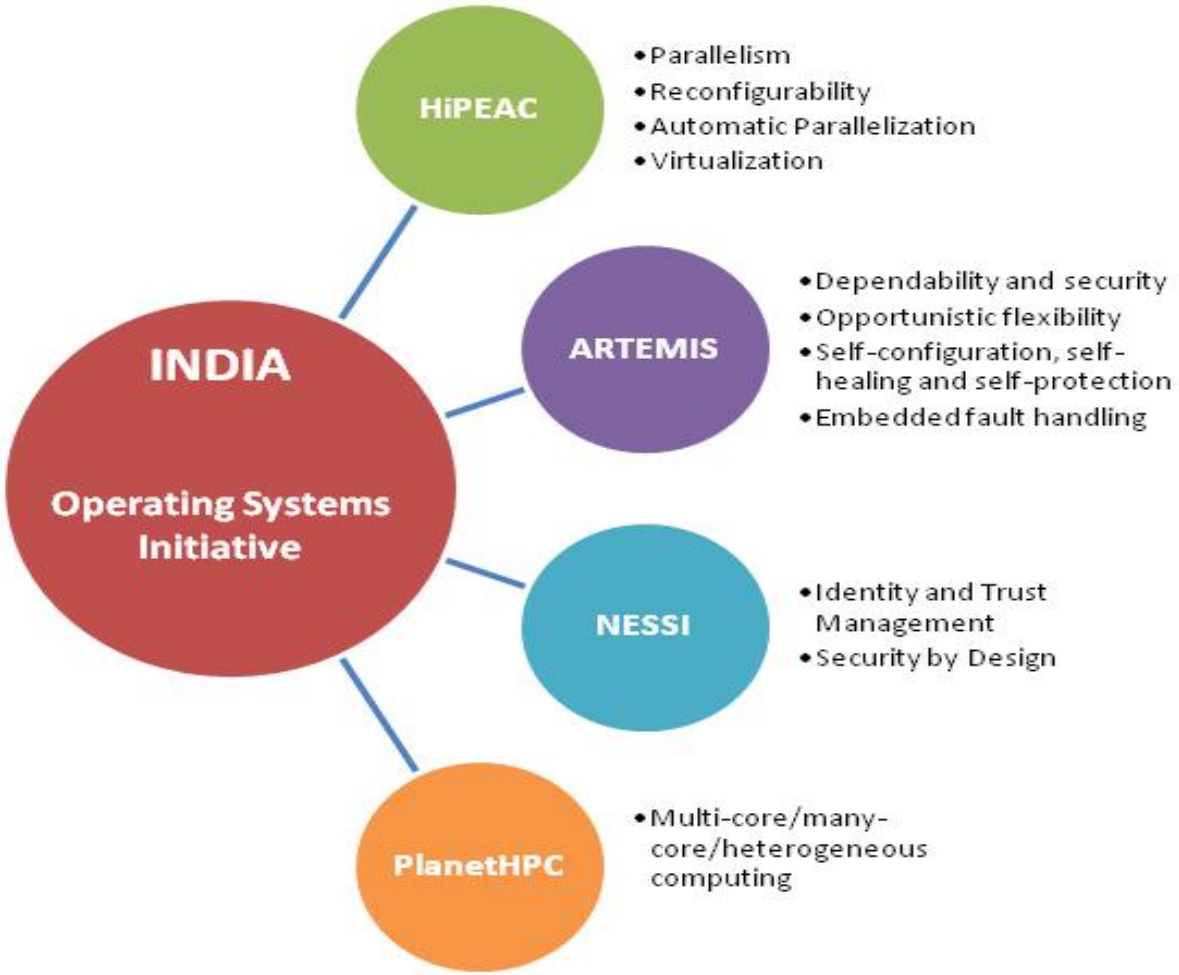
Mapping between EU and India



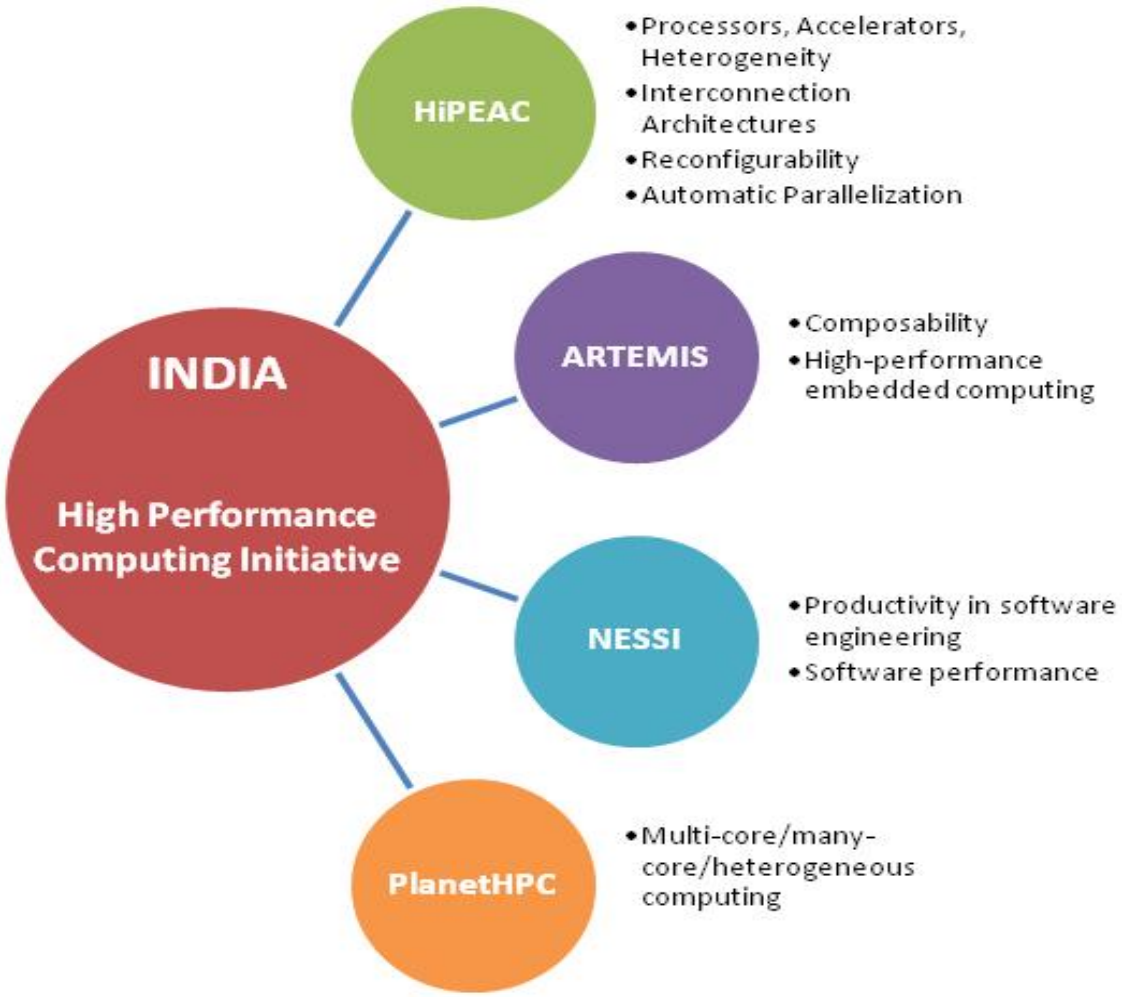
Initiatives Mapping



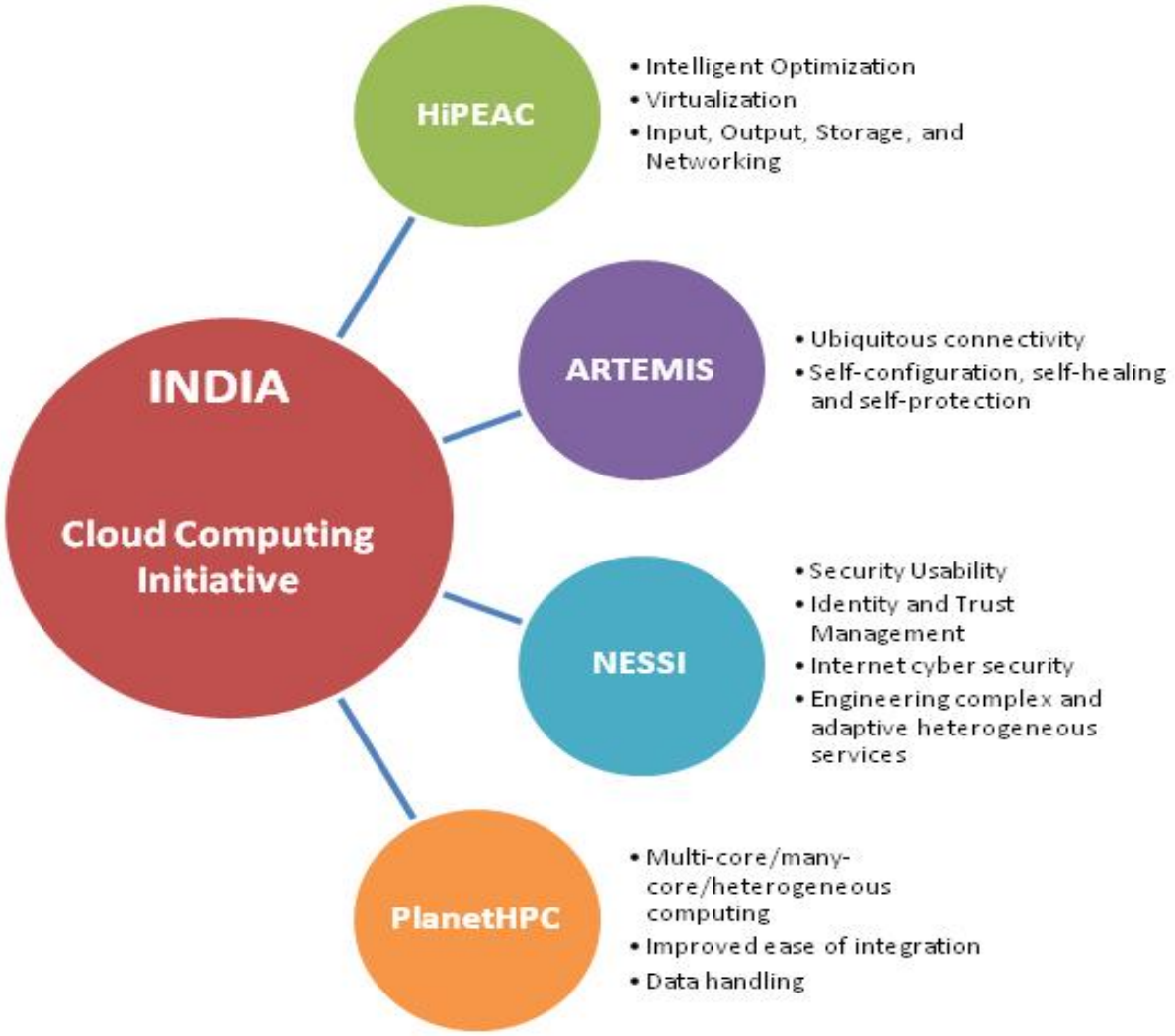
Initiatives (2) Mapping



Initiatives (3) Mapping



Initiatives (4) Mapping



Main funding authorities and research centers in India

- Funding: Department of Electronics and Information Technology (DEIT)
- Research activities:
  - CDAC
  - IISc and IITs
  - CSIR labs
  - Number of Technical Universities
- Type of ongoing activities:
  - BioInformatics, Ubiquitous computing, GARUDA grid, NKN, Computing applications,…

Statements from EU and India

- February 16, 2012

Europe Aims to Become World Leader in Supercomputing

  - The plan would increase Europe's public HPC spend from €630 million to €1.2 billion and pump a greater share of the money into development, training, and creating "new centres of excellence.“

- Sept. 2011

(India) Ministry of Science and Technology Sanctions 5000 Crore (1 b$) for Supercomputer Research

  - The ambitious project will be headed by Bangalore based Indian Institute of Science (IISc).

Proposed Actions

India: Incentivize R&D with PPP initiatives, IPR promotion covering education, awareness creation, IP exchange, related technology development and support to SMEs & start-ups, Financial support to start-up companies.

Planet HPC: Encourage SMEs, New access and business models, Migration pathways, Raise awareness, HPC pilot networks, Research & development activities, Visioning, Stimulate the market and user involvement.

ARTEMIS: Create new innovation eco-systems, Align Research Agendas for Embedded Systems, ARTEMIS repository, Centres of Innovation Excellence, Standards for Embedded Systems, Tool Platforms, Regulations, safety, security and digital trust certifications, Intellectual Property Management, Open Innovation and Open Source policy, Industry-Academia Collaboration, Research Infrastructure

Research Collaboration: EU vs India

		Heterogeneous computing systems	Locality and communications management	Software for heterogeneous multi-cores	Cross-component/cross-layer optimization	Next -generation processing cores	Architectures for the Data Deluge	Reliable systems for Ubiquitous Computing
Parallelism and Programming Models								
9.1.1.	Locality Management	x	x	x	x	x	x	x
9.1.2.	Optimizations programmer hints, tuning	x	x	x	x			x
9.1.3.	Runtime Systems and Adaptivity	x	x	x	x		x	x
Architecture								
9.2.1.	Processors, Accelerators, Heterogeneity	x	x			x		x
9.2.2.	Memory Architectures	x	x		x	x	x	
9.2.3.	Interconnection Architectures	x	x		x	x	x	
9.2.4.	Reconfigurability	x	x		x	x		
Compilers								
9.3.1.	Automatic Parallelization		x	x		x		
9.3.2.	Adaptive Compilation			x			x	x
9.3.3.	Intelligent Optimization			x	x	x		x
Systems Software and Tools								
9.4.1.	Virtualization	x		x	x		x	x
9.4.2.	Input, Output, Storage, and Networking		x		x		x	
9.4.3.	Simulation and Design Automation Tools	x			x	x		
9.4.4.	Deterministic Performance Tools	x	x	x	x	x	x	x

International cooperation

- Computing systems are managed in terms of optimised Hardware and Software components
- Europe has an edge in Semiconductor technologies with number of Internatoinal companies such as STMicro electronics, Infineon, ARM,…
- Has number of research centers for collaborative work, though limited in Industry-Academia networks
- India is a software powerhouse to complement.
- Number of National research institutes and international companies are active in India

Thank you

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