HiPEAC Vision 2025

HIGH PERFORMANCE, EDGE AND CLOUD COMPUTING

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HIGH PERFORMANCE, EDGE AND CLOUD COMPUTING

THE NEXT COMPUTING PARADIGM

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Building the next computing paradigm

The ‘next computing paradigm’ is the convergence of technologies including the web, cyber-physical systems (CPS), cloud computing, the internet of things (IoT), digital twins and artificial intelligence (AI) into a coherent, federated ecosystem.

European academic and industry leaders need to **act fast** to establish made-in-Europe technologies in this rapidly changing landscape. Technological offerings should **meet the needs of European markets**, while ensuring that European technology is synonymous with **quality and trustworthiness** in the minds of consumers across the globe.

The HiPEAC Vision for the European computing ecosystem is characterized by the following factors, which play to European strengths and establish a ‘European’ flavour of computing:

- Collaborative
- Federated
- Distributed
- Interoperable
- Open source
- Trustworthy (i.e. explainable, reliable, secure, safe and privacy-preserving)
- Sustainable

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HIGH PERFORMANCE, EDGE AND CLOUD COMPUTING

PRIORITIES FOR RESEARCH

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RECOMMENDATIONS RESEARCH PRIORITIES

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1. Technologies for a smart, interoperable, made-in-Europe computing continuum

- Foundation models and specialized action models, which need to be refined, optimized and reduced in size.
- AI-powered orchestrators for the edge that can combine compute components into executable applications.
- Orchestrating technologies that can analyse and select the best SAM for a particular task and dynamically activate them.
- Generative AI at the edge, with new ways of interaction (voice, gesture, eye movements).

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RECOMMENDATIONS
RESEARCH
PRIORITIES

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1. Technologies for a smart, interoperable, made-in-Europe computing continuum

- Digital envelopes to enable services across the continuum: interoperable runtime systems, service and code migration, optimization for latency, privacy, security, etc.
- AI-assisted software development environments, prioritizing correctness, safety, security, confidentiality and regulatory compliance.

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RECOMMENDATIONS RESEARCH PRIORITIES

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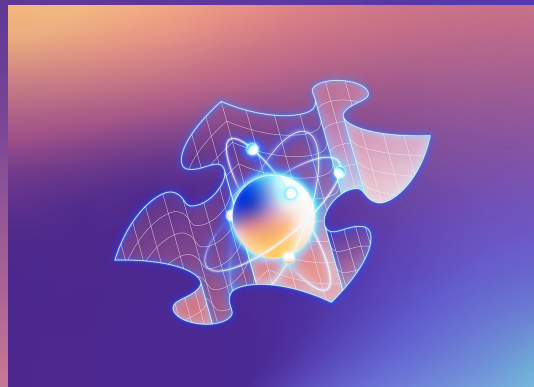
2. Next-generation, designed-in-Europe hardware for the NCI

- Specialized hardware for the edge, able to support services, orchestrators and specialized action models (SAMs) in federated networks.
- Non-volatile memory for direct edge execution, near- or in-memory computing.
- Hybrid and non-digital accelerators, moving from exact computations (digital) to approximate computing (Ising, Bayesian, stochastic, etc.).
- Open AI assistants for hardware development, focusing on open domains such as architecture search.



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RECOMMENDATIONS RESEARCH PRIORITIES

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3. Future-proof, connected safety-critical systems

- Cross-domain research integration: shared ontologies, modelling tools, and evaluation frameworks to align diverse technical disciplines under common goals.
- Solutions that maximize interactions between safety, security and performance.
- New dependability frameworks: modular and adaptive safety-security-performance models, extending hazard-analysis techniques like STPA.
- Real-time resilience: runtime verification, feedback mechanisms and uncertainty quantification tools that ensure dependable operation in dynamic and unpredictable environments

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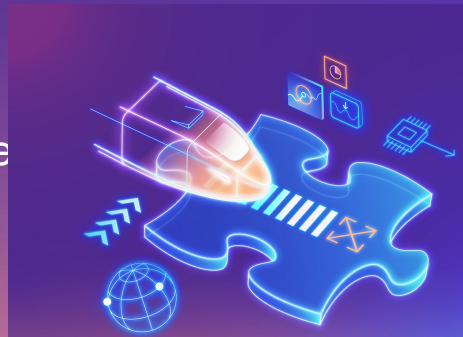

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4. Securing the computing continuum

- Scalable technologies for supply-chain tools to identify vulnerabilities at code and component levels.
- Scalable security analyses at orchestrators, services, and communications levels.
- AI models for threat detection and autonomous systems for mitigation, preferably based on European, open foundation models.
- Tools to detect and secure against AI model vulnerabilities, including prompt injection vulnerabilities.

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5. Sustainable digital systems for future generations

- Life-cycle models for digital products and services, integrated into design decisions and research outcomes.
- Computing solutions that can report sustainability metrics to orchestrators, thereby enabling digital product passports.
- Sustainable-by-design methodologies and circular business models.

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