HiPEAC Vision 2025

HIGH PERFORMANCE, EDGE AND CLOUD COMPUTING

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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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1. **Core technology topics: The next computing paradigm**

- Edge-to-cloud computing architectures, considering scalability, latency, privacy and interoperability.

- Digital envelopes: secure, context-aware services that operate across devices and locations.

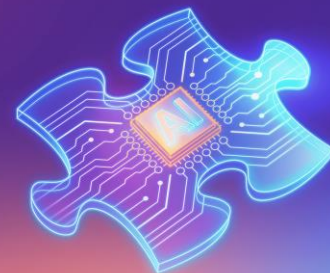- Orchestrating technologies to dynamically coordinate microservices.

**RECOMMENDATIONS
FOR EDUCATORS:
TECHNOLOGY TOPICS**

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2. **Core technology topics: Artificial intelligence for the NCP**

- Specialized action models: distributed, domain-specific AI models designed for edge execution.

- AI orchestration concepts, such as composing compute components into executable applications tailored to specific user needs.

- AI interoperability concepts, including API design, non-functional properties (such as energy, reliability and secuirty), and open AI protocols.

3. Core technology topics: Next-generation hardware

- Energy-efficient hardware for the edge, including concepts such as low-power processor architectures and in-memory computing.

- Accelerators for specific workloads, especially AI.

- Non-digital hardware including neuromorphic and quantum.

- Exact vs. approximate computing, including stochastics, Bayesian and Ising approaches.

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4. Core technology topics: AI-based tools

- AI tools for software development, such as Copilot, Gemini Code Assist, Code Llama, and Codestral.

- AI tools for hardware design, such as ChipNeMo, ChipGPT, and ChatEDA.

- Limitations and appropriateness, including safety, correctness and bias concerns when using AI tools to develop software and hardware.

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RECOMMENDATIONS FOR EDUCATORS: CROSS-CUTTING TOPICS

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1. Cross-disciplinary systems thinking

- Systems-level integration: full-stack design, from sensors to software to human-computer interfaces, focusing on real-world use cases in areas such as mobility and health .

- Dependability concepts and modular safety / security / performance modelling in systems design.

- Cross-disciplinary projects, promoting terminology alignment and shared models across different domains.

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2. Secure computing systems in a connected world

- Key topics (in addition to basic cybersecurity concepts):

- Software supply-chain security and vulnerability detection.

- Secure orchestration and service authentication.

- AI for cybersecurity including threat detection using machine learning, anomaly detection, and federated cybersecurity models.

- AI security challenges, including adversarial machine learning, prompt injection risks in LLMs, and defensive design strategies.

3. Sustainable computing systems

- The life-cycle of computing devices and systems: the full environmental impact of IT systems, from raw material extraction to end-of-life disposal.

- Environmentally responsible system design: integrating sustainability metrics into design tools and prioritizing low-power solutions.

- Circular business models, including designing for repair and reuse, and prioritizing hardware as a service.

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4. Made-in-Europe technology innovation

- Ecosystem model of science and technology clusters: startup incubation, funding models, and collaborative innovation environments (including real-world case studies such as Silicon Valley).

- Commercialization literacy: the fundamentals of tech transfer, intellectual property, and spin-offs, with mentors to guide students.

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