Visions of ECS beyond 2030

Analysis of Key Messages from the LTV and the 5 KDT Workshops

Sven Rzepka, *EPoSS Scientific Council*

Visions of ECS beyond 2030

Joint Workshop of the 3A Scientific Councils on 14 Sep 21

Electronic Components and Systems

Agenda

TIME	TOPIC	SPEAKER
09:30	Introduction by the moderator: workshop guide and agenda	Patrick Cogez, *AENEAS*
09:35	Main ideas under development in the Long Term Vision Chapter	Dimitrios Serpanos, *Chair, ARTEMIS Scientific Council*
10:00	Inputs as derived from the KDT Workshops	Sven Rzepka, *Chair of EPoSS Key Technology working group*
10:10	Future of Computing	Heike Riel, *IBM Research*
10:25	Integrated Photonics	Dries Van Thourhout, *Ghent University*
10:40	Flexible Electronics	Ralf Zichner, *Fraunhofer ENAS/ OE-A*
10:55	Smart Networks and Services long term ECS requirements	Alexandros Kaloxylos, *5G Infrastructure Association*
	Break	
11:20	Linking HW and SW for AI	Elisa Vianello, *CEA-LETI*
11:35	TransContinuum Initiative	Michael Malms, *mm-it4you*
11:50	Open Source HW and RISC-V	Luca Benini, *University Bologna and ETHZ*
12:05	Q&A and collecting inputs from the audience	
12:25	Wrap up by moderator	Patrick Cogez, *AENEAS*

Jointly organized by the 3As (Aeneas, Insight, EPoSS), the workshop had 170 registrants.

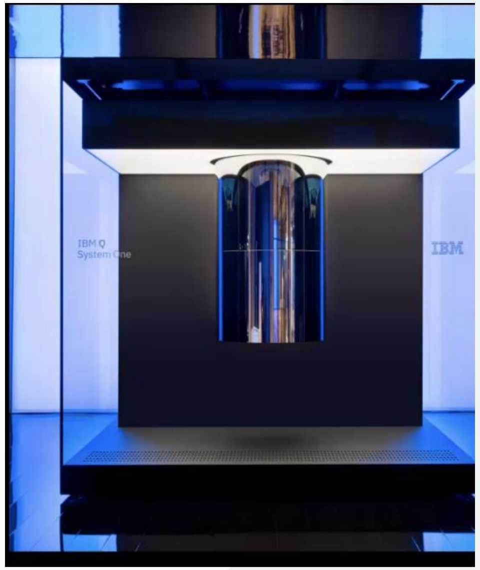
Heike Riel, *IBM Research*

Future of Computing

Electronic Components and Systems

- Key drivers
  - Energy Efficiency
  - Data Explosion and AI
  - Security and Privacy

- Whole array of research threads
  - Towards perfect analog computing
    - Improve materials
    - Compensate imperfections with device architecture and algorithms
  - Technology for AI hardware
    - Traditional CMOS with algorithms and architectures for approximate computing
    - In-memory computing with algorithms and arrays for analog memory elements
    - Biologically plausible networks
  - Quantum computing
    - Many potential qubit technologies: superconductors, trapped ions, engineered defects, spin, quantum dots, topological devices
    - Challenges: cryo-electronics, nanoscale physics, engineering of nanostructures, exploitation of new phenomena

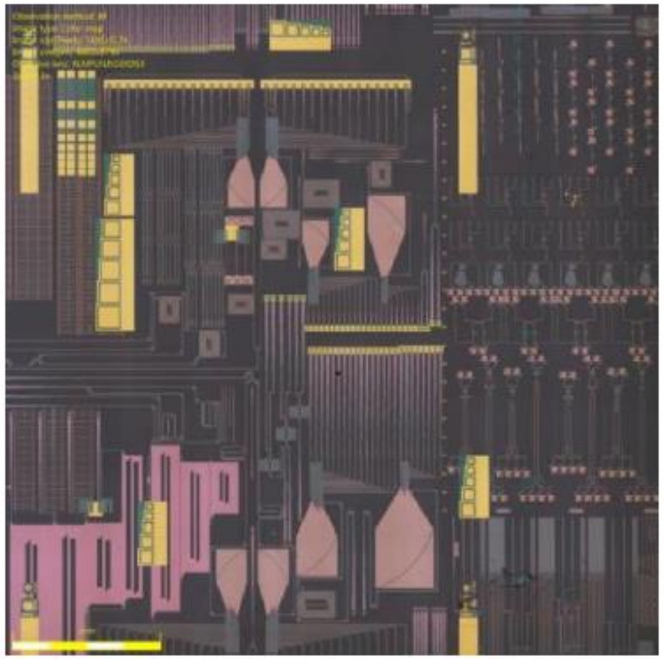


Dries Van Thourhout, *Ghent University*

Integrated Photonics

Electronic Components and Systems

- Areas of needed progress in SoI and SiN PIC platforms
  - Light source integration
  - Phase modulation (electronic and thermal)
  - Very low loss linear and non-linear waveguides also in SiN
  - Integrated detectors also in SiN
  - Optical isolators / circulators
  - Non-volatile programmable functions
  - Integration with electronics



Courtesy of imec

Ralf Zichner, *Fraunhofer ENAS/ OE-A*

Hybrid, Flexible and Printed Electronics

Electronic Components and Systems

- Circular economy of flexible electronics
  - Green production and green products
- Process technology
  - Towards more robust, lightweight, flexible and stretchable electronic systems
  - Printed flexible Q-dots and microLED
  - Seamless integration of printed hybrid electronics systems on top of any 3D object
- Applications
  - Printed flexible medical patches to detect body vital parameters, disease patterns and show aging rate

Courtesy of OE-A

Alexandros Kaloxylos, *5G Infrastructure Association*

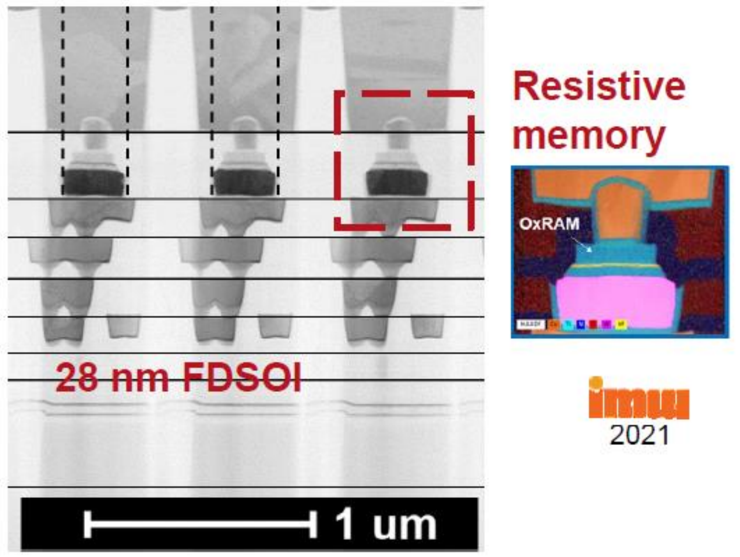
Smart Networks and Services

- Fully distributed AI/ML solutions for network virtualisation
  - Cloud, deep edge, end devices…
- Transceivers for higher spectral efficiency, reduced power consumption, high density digital logic, chip-package-antenna co-design
- Human friendly radio systems - Safety
  - Handle increased density, higher frequency ranges, control EM fields
- Self-powered and energy harvesting devices

Elisa Vianello, *CEA-LETI*

Linking Hardware and Software for AI

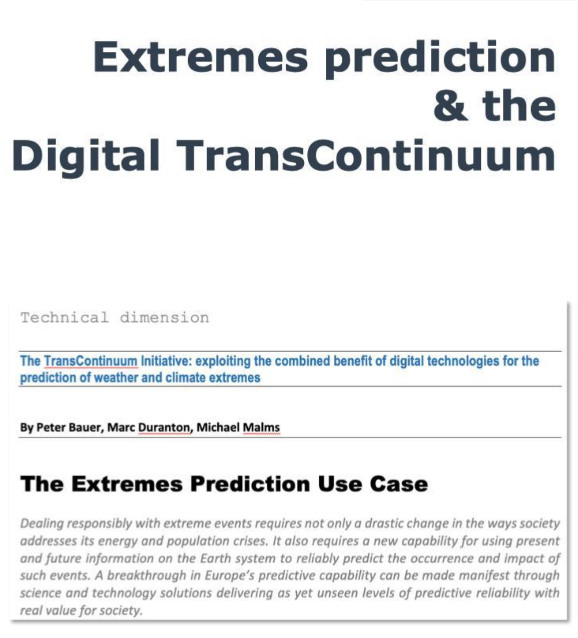
- Need for Frugal Edge AI accelerators
- Brain-inspired computing
  - Massively parallel
  - Co-location of computation and memory
    - Resistive memory
  - Match circuit time scale with input signal dynamics
    - Spike coding
  - Embracing the statistical nature of emerging memories
    - Low precision neural networks
    - Bayesian neural networks
- Frugal AI devices - Combination of Algorithms, Technologies and Circuit Solutions



Courtesy of CEA-LETI

Michael Malms, *mm-it4you*
Trans Continuum Initiative

- From deep edge to cloud to HPC
- Case studies of digital twins in various settings
  - Industry, urban air pollution, extreme earth phenomenon predictions
- Research treads identified so far
  - Need for increase in computational power
    - New architectures : Quantum annealing
    - New paradigms : Stochastic computing
  - Automated digital twin development and application
    - Derive physics from data, train intelligence
    - Automatic detection of gaps between system and digital twin
  - AI/ML developments
    - Reinforcement learning
  - Distributed computing, distributed AI/ML solutions
    - Dynamic adjustment (of edge system) vs. backend
    - Overcome data transfer bottleneck



Extremes prediction & the Digital TransContinuum

Technical dimension

The TransContinuum Initiative: exploiting the combined benefit of digital technologies for the prediction of weather and climate extremes

By Peter Bauer, Marc Duranton, Michael Malms

The Extremes Prediction Use Case

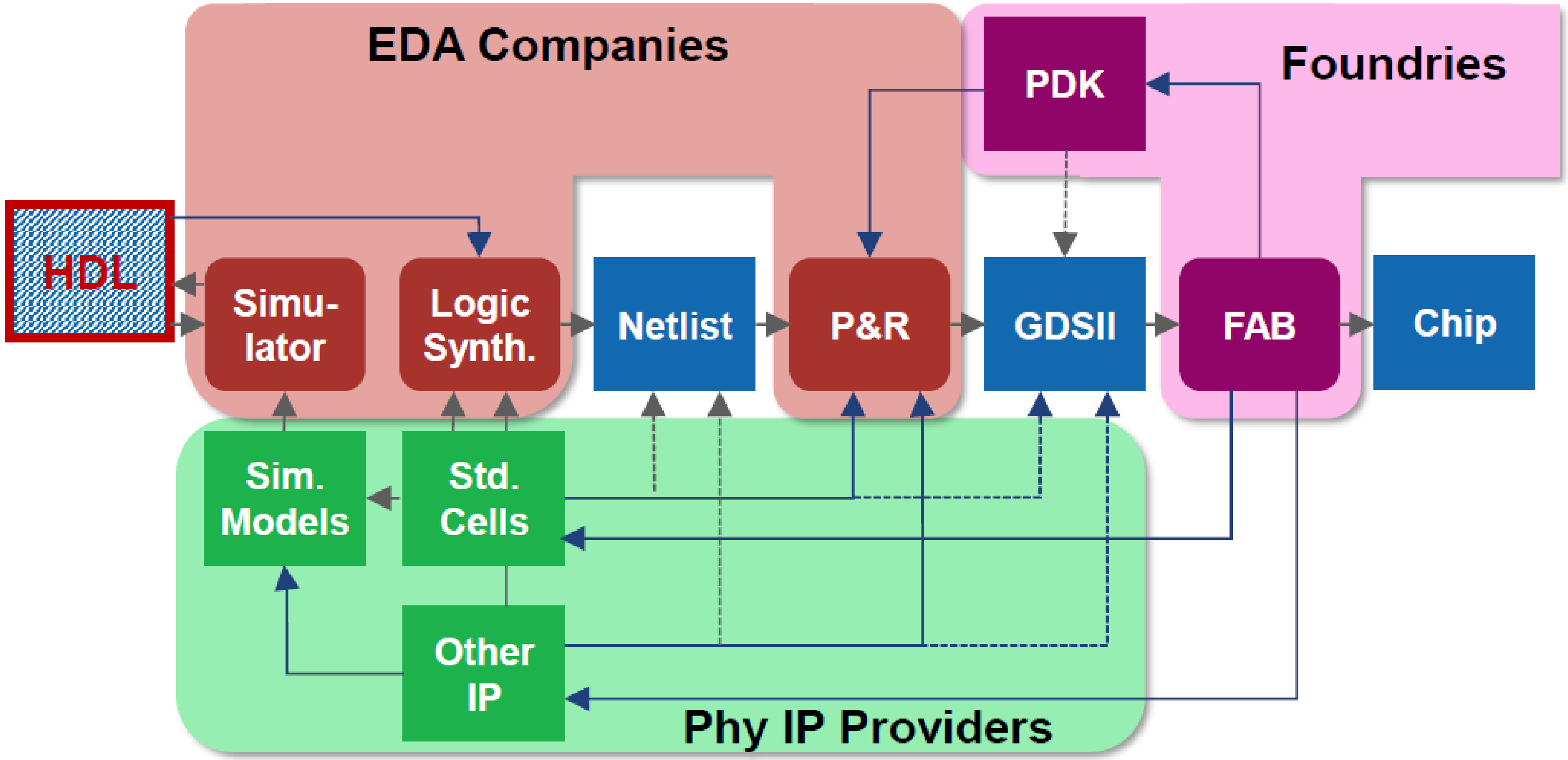
Dealing responsibly with extreme events requires not only a drastic change in the ways society addresses its energy and population crises. It also requires a new capability for using present and future information on the Earth system to reliably predict the occurrence and impact of such events. A breakthrough in Europe's predictive capability can be made manifest through science and technology solutions delivering as yet unseen levels of predictive reliability with real value for society.

Courtesy of the TransContinuum Initiative

Luca Benini, *University Bologna and ETHZ*

Open Source HW and RISC-V

- Open source hardware as an innovation facilitator
- Requires access to advanced EDA tools with licencing compatible with open-source hardware



Courtesy of ETH Zürich

Findings from the 5 KDT workshops

Technology Fields

Quantum Technologies:
Q-Sensing, Q-Computing, Q-Communication

AI Technologies:
Hierarchical Architecture (AI at the edge … SoS), Trustable / Certifiable, Digital Twins (full-scale … very compact)

Autonomous Systems:
Multifunctional Integration and Functional Electronics, Trust-worthiness (Reliability, Safety, Self-X, Security, Robustness)

Materials: Highly performant, Efficient fabrication, Inherently green, Hazard-free, Recyclable, Bio-based, Lifecycle optimized

E C S
Electronic Components and Systems

Findings from the 5 KDT workshops

Application Fields

E C S

Electronic Components and Systems

Mobility: Electrical, connected & autonomous vehicles

Energy: Multimodal bidirectional sustainable generation, distribution and use – across Europe

Digital Industry: Industry 4.0, Collaborative Robots

Agrifood & Natural Resources: Fully autonomous systems for smart farming, biodegradable materials, sustainable farming, animal welfare

Health & Wellbeing: Individualized / personalized medicine & care for inclusive self-determined life without dependence

Digital Society: Comprehensive services with full privacy

Summary: Joint Vision Beyond 2030

Energy: Multi-modal bidirectional

Digital Industry: Industry 4.0, Collaborative Robots

E C S

Electronic Components and Systems

Mobility: Electrical, connected & autonomous vehicles

Health & Wellbeing: Individualized / personalized medicine & care

Ubiquitous printed electronics

New Paradigms Compiled in the **LTV Chapter**

Agrifood & Natural Resources: smart, autonomous, sustainable farming, bio-degradable materials, animal welfare

Open Source HW as innovation enabler

Programmable photonic ICs

Autonomous Systems:

Multifunctional Integration and Functional Electronics

Wafer-scale heterogeneous **silicon photonics**

Digital Society: Comprehensive services with **full privacy**

New materials, devices, technology, infrastructure including measurement

Materials: Highly performant, Life-cycle optimized

Smart Networks: Trustable AI everywhere, efficient use of spectrum

Trustable & Sustainable **Electronics**

AI HW from approximate to analogue computing

Frugal AI devices: Algorithms, technologies & Circuit solutions

Quantum Technologies: Q-Sensing, Q-Computing, Q-Communication