Cloud Working Group

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Nanotechnology-inspired Information Processing Systems of the Future

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A Start

- Energy efficient computing
  - Can nanofunctions bridge the gap between application needs and device implementations?
  - Collective computing at scale
- Convergence of storage and memory
  - What memory design space does not have a solution -- a major quest
- Energy efficient communication
- Redefining interfaces –software-hardware interface
- Heterogeneity – a challenge for software and hardware

Beyond Moore and Von Neumann

- Cross Layer Innovation
  - CMOS scaling at the end of roadmap
  - Multiple walls – power, memory, I/O bandwidth
  - Specialization at various levels of design
    - Tap synergy between devices, circuits, architectures, computational models
  - Monolithic 3D integration – closer memory & compute and shorter & dense interconnect
  - Blur between memory and storage
  - What is the impact of new devices or computational models?
    - On compute, communication and memory
    - Algorithm has big impact on the data movement

Big Data

- Video data expected to dominate networks
  - 82% of Internet traffic by 2020 will be video (Cisco White Paper 2015-2020)
- Unstructured data types, irregular and streaming data accesses
  - Multi-Modal Data and Metadata including video/audio/text with location, timing, and other context information.
- Potential for inexact and approximate computing
  - Not all pixels are equal
- Workload consolidation and collaborative processing

Heterogeneity

- Specialization leads to diversity
- CPU, GPU, FPGAs + Neuromorphic processors, Quantum, Application Specific processors
- Software stack and programming models
- Impact of hardware diversity on operating system design and resource management
  - What additional OS layers are needed?

Sustainable Data Centers

- Software: End devices may have long life
  - Microscopes have lifetime of 10-15 years
  - Power-grid has end devices in place for 20 years
  - Smart City initiatives plan sensors installment for multiple years (too expensive to replace them because new HW/SW shows up).
- Software: Compatibility for long periods of time
  - Data format and computational models compatibility
  - Software lifecycles – OS upgrades
- Hardware
  - Scalable and adaptive specialization
  - Ability to integrate new technologies

- Energy, Area and Environmental Footprint for Data Centers is large
  - How do we design eco-friendly data centers?

- Sustainability of data, equipment, platforms is an issue.

Distributed Cloud + Edge intelligence

- Compressed Computing
  - Zettabyte Era – need to compress data and work on compressed streaming data
    - 2.3 ZB per year by 2020 (Cisco White Paper 2015-2020)
- Encrypted Computing
- Dynamic workload partitioning
  - Internet of Things will need edge computers to do partial computing before connecting to cloud
  - Cloudlets, edge computing, fog computing to assist clouds (cloud surrogates)
- Influence of new communication technologies on increased connectivity between edge devices
- Hierarchical cloud computing
  - Three tier cloud architecture – end device, edge device (cloudlet), cloud