Emerging Architecture Session

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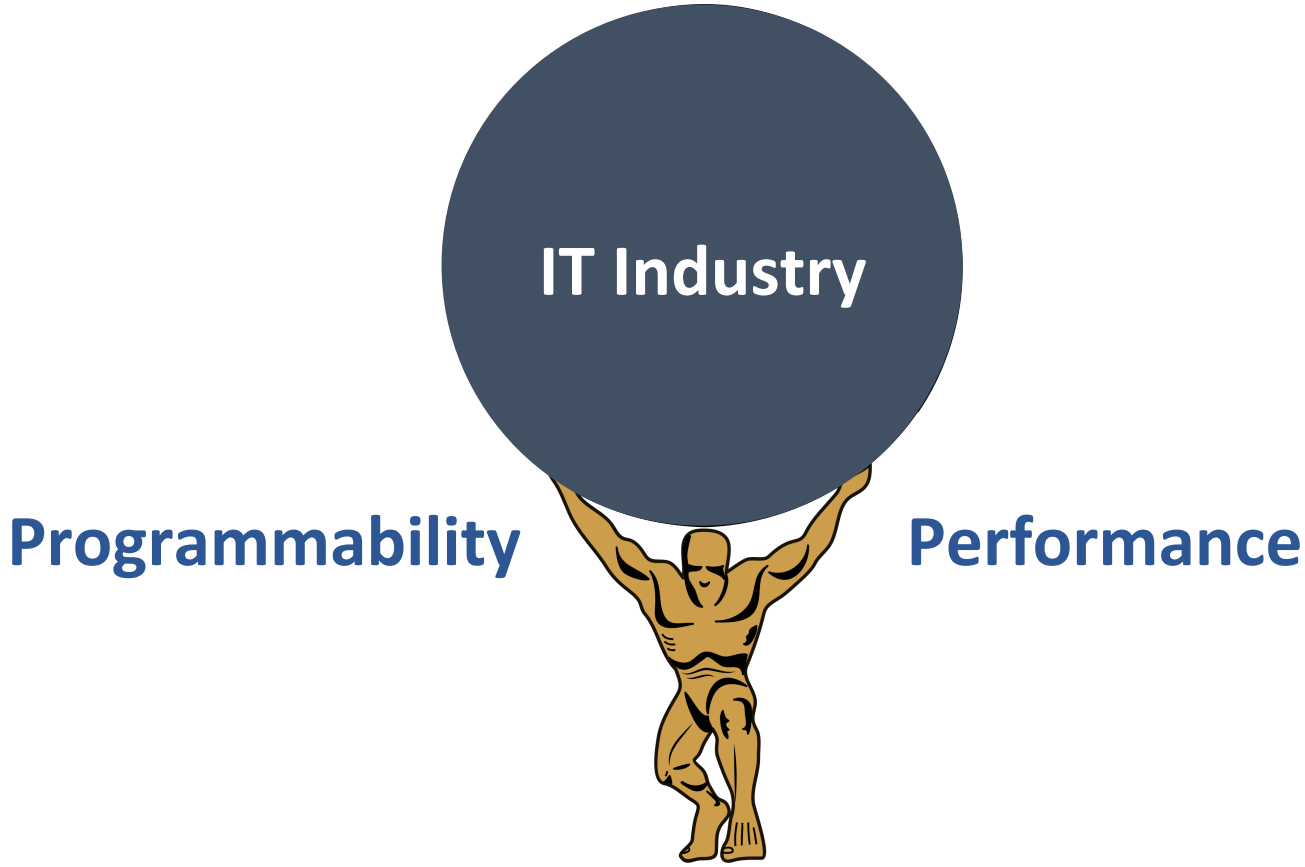
NSF CSR/NeTS 2019 Joint PI Meeting

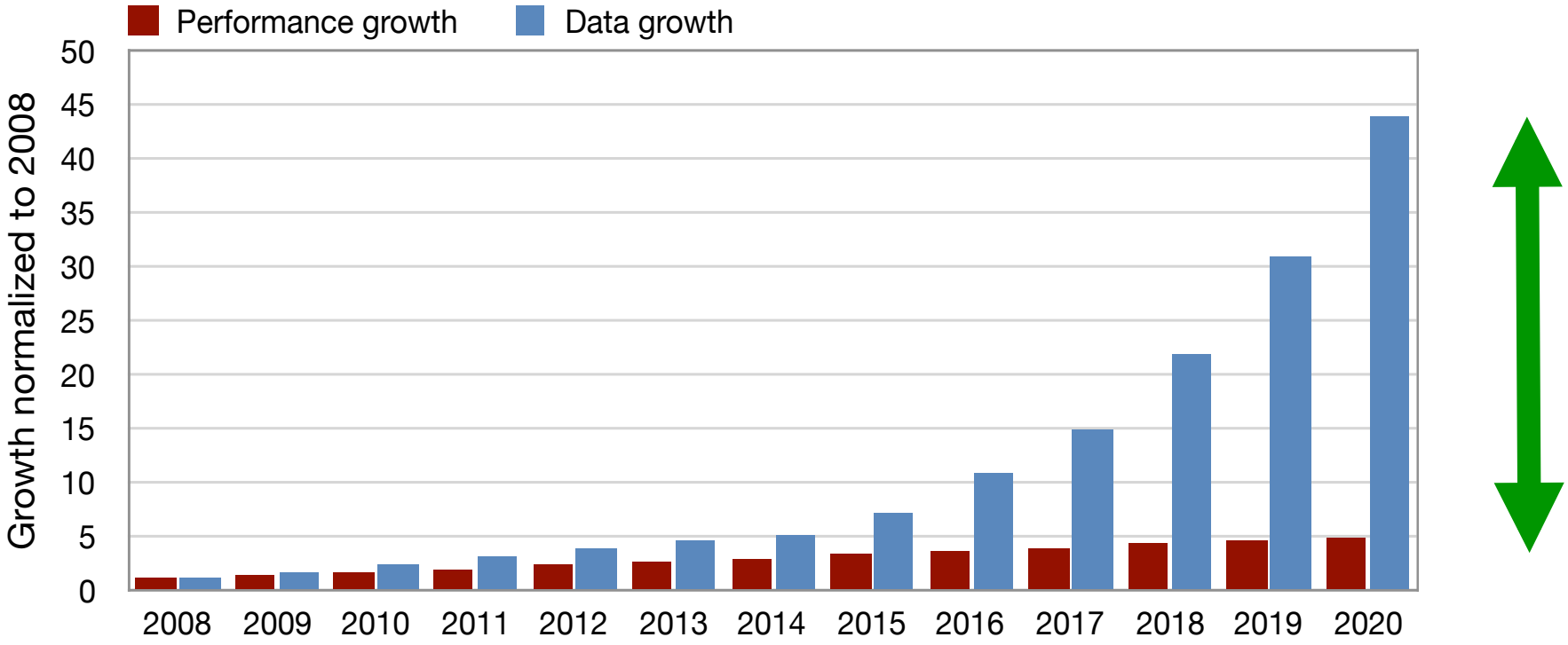
General-purpose processors

Main drivers for revolutionary advances in IT industry



General-purpose processors

Growing gap between data and compute



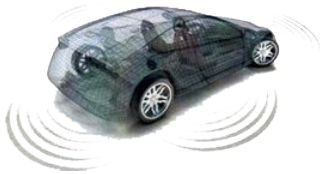
- Data growth trends: IDC's Digital Universe Study, December 2012
- Performance growth trends: Esmaeilzadeh et al, “Dark Silicon and the End of Multicore Scaling,” ISCA 2011

Power/energy efficiency is a primary concern

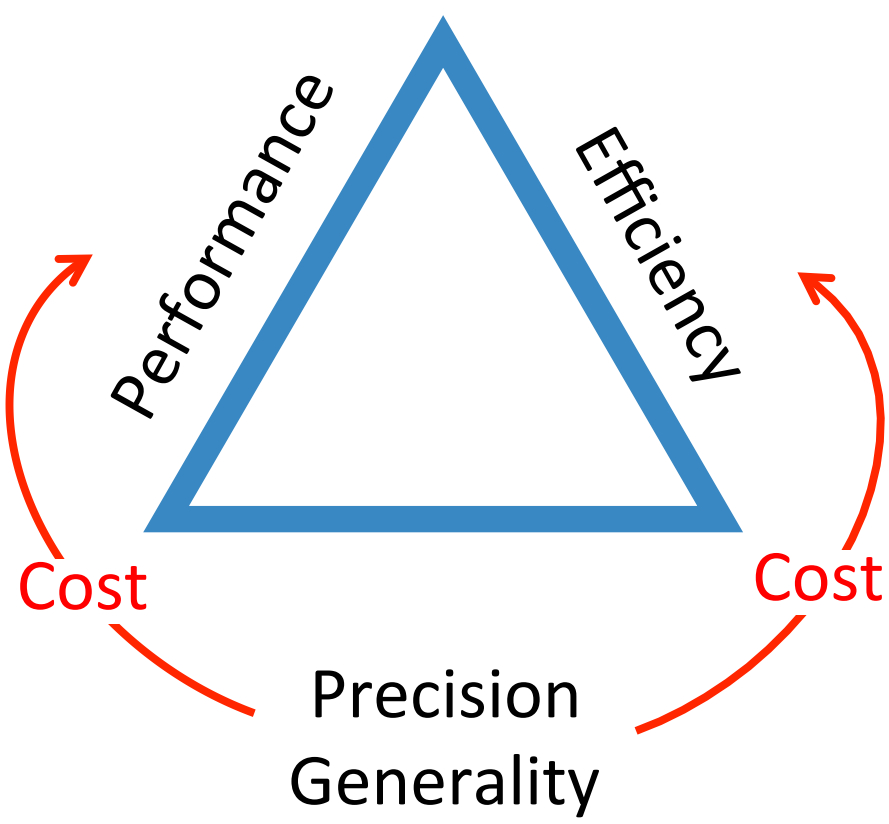
Data Center

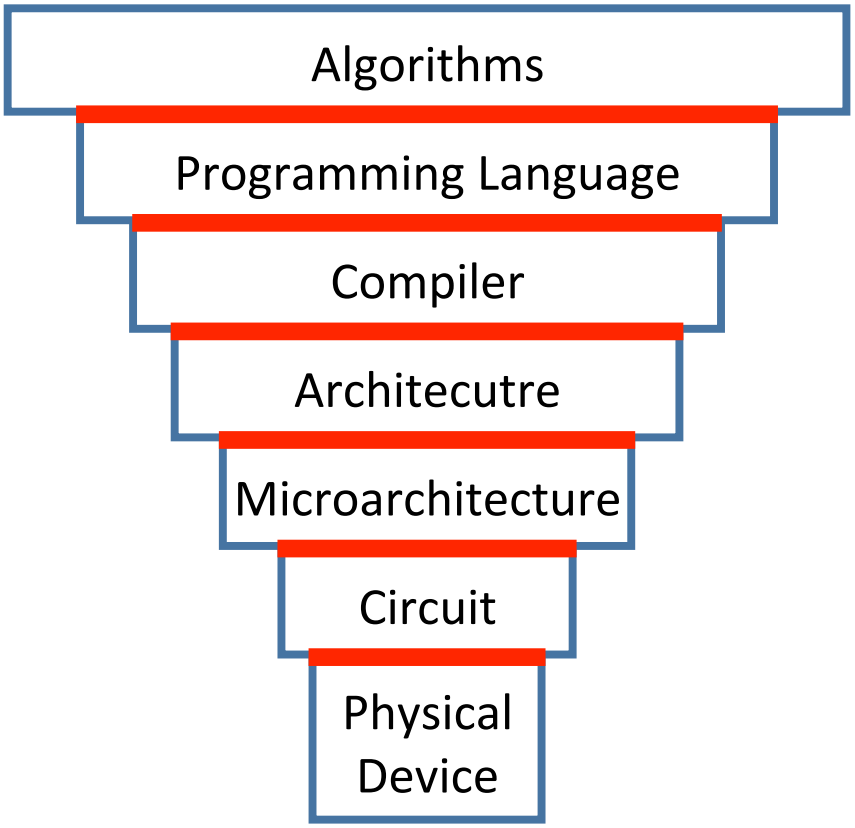
Mobile

Internet of Things

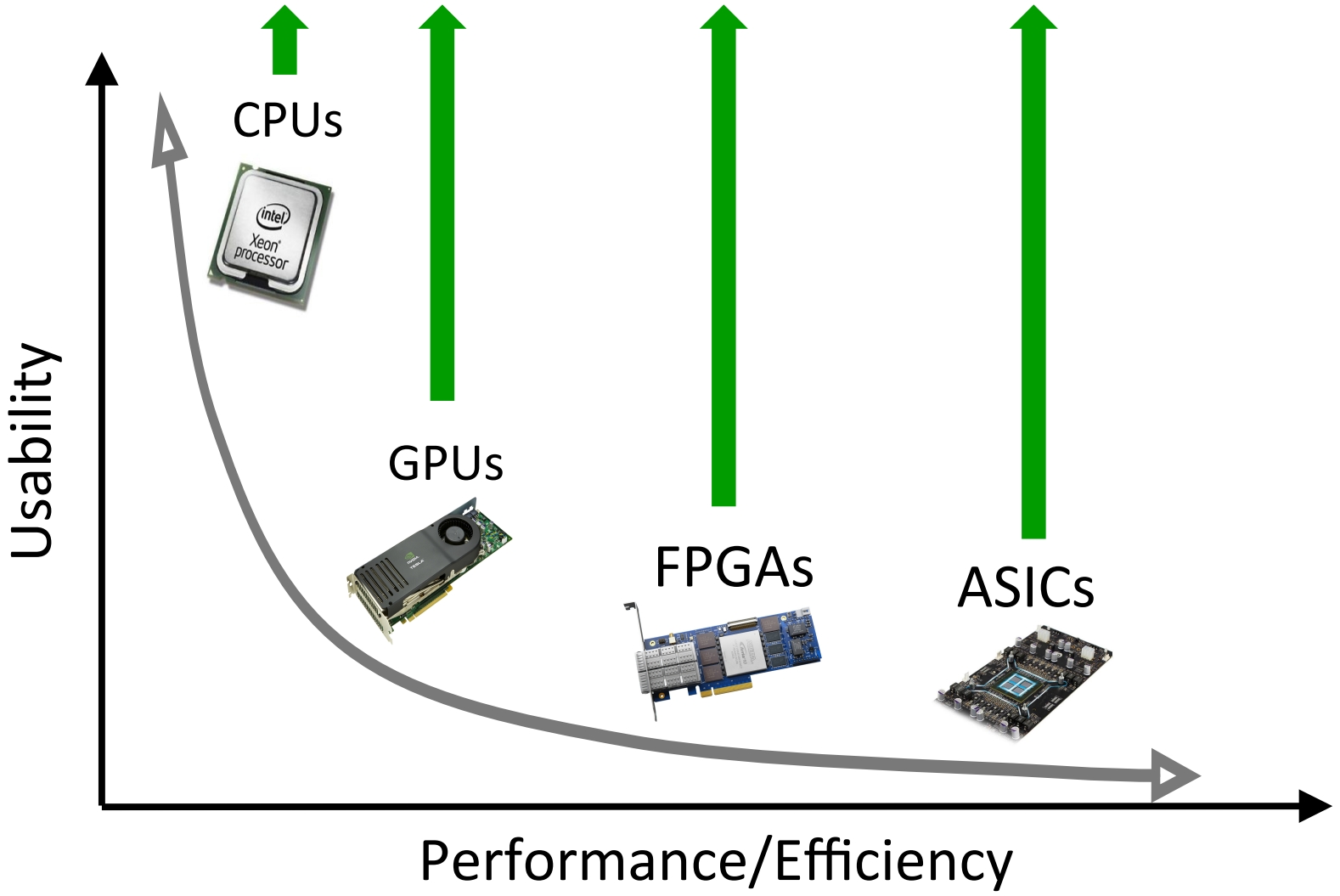


Rethinking abstractions





Usability vs. performance/efficiency



Programming/Compiler Challenges

1. Redefining hardware/software abstractions that enable updating emerging architecture without redoing the software stack
2. Enabling future-proof software development that will not only work, but perform well, on hardware that did not exist when the software was written.
3. Language and programming constructs that enable programming with hardware architectures such as analog processing engines, non-volatile memory subsystems, reconfigurable fabric, accelerators, Application-Specific ICs, etc.
4. Enabling end-to-end application development when multiple domains of algorithms is necessary.

System Challenges

5. Moving from domain-specific architecture to domain-specific computational stack.
   - Isolation
   - Multi-tenancy
   - Virtualization
   - etc.
6. Tools and techniques for performance analysis and tuning when performance-opaque firmware and emergent architectures are hard to characterize.
7. System stacks that can seamlessly navigate trade-offs among performance and privacy, security, reliability, predictability, etc.

Architecture Challenges

8. Balancing general-purpose versus special-purpose designs
   - Applications are not kernels!
9. Getting the most from constrained hardware budget (Power/Energy, Storage, Battery, Bandwidth) and enabling new capabilities.
10. Enabling developers to designing their own special-purpose hardware and its associated stack
    - Open-sourcing hardware and its stack!
    - Democratization of hardware design
11. Enabling emerging hardware architectures and paradigms to improve other aspects of the system such as privacy, security, reliability, predictability, etc.

Full-Stack Approach towards Research and Education in Emerging Architectures

- Programming Interfaces
- Operating Systems Abstractions
- Compilation and Interoperability
- Modeling, experimentation, and emulation toolsets
- Not just performance: privacy, security, predictability, reliability, etc.
- Moving forward from CPU for everything as well as accelerator for one domain
- Cross-Disciplinary Education and Tools for Breaking the Silos
- Evaluation for emerging domains requires flexibility in terms of existing applications and established benchmarks; avoid overfitting!