Open Domain-Specific Accelerators: What are they and why should they matter to cloud and network providers?

Presented by: NETRONOME
Today’s Presenters

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Agenda

• Introduction
• Why domain-specific architecture-based silicon
• Open architecture for chiplets-based SoC designs
• Domain-specific accelerator reference architecture
• Technical and business challenges
• Call for industry collaboration
• Q&A
Cloud-based Services Driving Data Growth

• Cloud-based services
  – Content delivery (CDN)
  – Social media, messaging
  – Storage
  – Data Management
  – Big data processing
  – IoT services
• Services hosted in large and hyperscale data centers
• Virtualized infrastructure
  – Based on SDN and NFV

Source: Cisco VNI Global IP Traffic Forecast, 2017–2022
Accelerating the Servers

• Bandwidth demands have significantly outgrown CPU performance
  – Virtualization adds to load on server CPUs
• Domain-specific accelerators offload processing from CPUs
  – SmartNICs, machine learning and inference coprocessors, security processors etc.
  – Increases application performance
  – Releases CPU cores for other revenue earning workloads
• Accelerators should integrate best-of-breed components
  – Processors, hardware engines, memory and I/O peripherals
Chiplets and SoC Development

• Chiplets are silicon die for subsystem components
  – Alternative to monolithic SoC design
  – Have been widely used where an SoC uses components developed on different silicon technology – eg. Analog + DSP or processor
  – Increasingly being used to provide modular solutions

• Most chiplets so far have been used in a closed development environment

• An open chiplet ecosystem will enable the wider use of chiplets and accelerate SoC development
Chiplet Use Cases

• AMD EPYC Processors
  – 7nm CPU chiplets (Zen 2)
  – 14 nm I/O die

• Marvell MoChi™
  – Smartphone application
  – CPU, GPU, application processor and DRAM on MCM
  – Connects to LTE Modem and WiFi modules

• High-Bandwidth Memory
  – 3D stacked memory with interposer and wide parallel standard interface
  – Offered by multiple memory manufacturers in volume production.
Open Domain-Specific Accelerator (ODSA) Workgroup

- Industry initiative driven by seven leading silicon companies
- Developing an open architecture for domain-specific accelerators
- Enables chiplet-based silicon design to be composed of best-of-breed components
  - Includes processors, accelerators, and memory and I/O peripherals
- Implementing open specifications contributed by participating companies
Audience Poll #1

- Is your company looking at domain-specific accelerators to meet your cost-performance goals?
  - Yes, and working on solutions now
  - Yes, and will need solutions within 1-2 years
  - Yes, will be required for future roadmap
  - No, this is new to us
Exponential Costs of Monolithic Silicon Development

- Designs are too costly at advanced nodes
- Impossible to justify for smaller markets
- Only the largest companies can afford
- Stymies domain-specific innovation
- Limits choice of components – both specialized and commodity/generic

Keith Flamm, Nov ‘17 (Measuring Moore’s Law; Evidence from Price, Cost & Quality Indices) Global Foundries, semiengineering.com (“How much will that chip cost?”)
How Does Performance Scale Post- Dennard & Moore’s Law?

**Today’s problem:**
- Dennard Scaling has ended
- Moore’s Law slows
- ILP (Instruction Level Parallelism) era finished
- Amdahl’s Law ends the “easy” multicore era

**Today’s solution:**
- Domain Specific Architectures & Languages
  - Optimize the architecture for domain characteristics
  - Requires more intimate knowledge than GP CPUs
  - Do less, but do it faster and more power efficiently
  - Programming model matches specific domain
Examples of Domain Specific Architecture Processors

• Tailor architecture to a domain
  – Devices - programmable, not hardwired
  – Integrated application and deployment-aware development of devices, firmware, systems, software
  – Domain-specific languages for ease of use

• Attributes of a Domain-Specific Architecture
  – Parallelized data processing
  – Function-specific logic
  – Application-aware data management
  – Application-aware flow control
Domain-Specific Silicon Delivers Higher Performance/Watt

Google TPU vs. CPU and GPU

Source: “An in-depth look at Google’s first Tensor Processing Unit (TPU)”, Google Cloud, May 2017

Netronome NFP vs. CPU and FPGA

Source: Netronome based on internal benchmarks and industry reports related to Xeon CPUs and Arria FPGAs
Open Architecture for Chiplets-Based Domain-Specific Accelerators

Switch Fabric interconnect the Logic Blocks inside the NFP device

Open chiplets connectivity specification
Reference Multi-Chiplet DSA Architecture

- Reference multi-die architecture for DSAs derived from monolithic and decomposed into individual chiplets:
  - A network I/O chiplet
  - A RISC CPU chiplet
  - A DSA chiplet which may be implemented as:
    - An FPGA
    - A many-core RISC processor
    - Domain-specific logic
  - A switching and interface chiplet to which all the other chiplets are connected
- These chiplets are now packaged together on a common substrate
- The chiplets will have to implement comm agents to support inter-die networking
Networking and Inferencing Package on Demo System

- LR SerDes
- Bridge
- NFP
- Arm RISC-V
- FPGA

To Host
- PCIe-3, 8 Lanes, 36 Wires
- What is the I/O Protocol? Maximum Number of Interconnections?
- PCIe-3, 8 Lanes, 36 Wires
- Networking Package
- Inferencing Package

LR SerDes - 112Gb/s XSR, 1Tb/s BW, 8 Lanes, 30-50 Wires

What are the I/O Protocols?
What is the Maximum Number of Interconnections for Each Protocol?
What is the Total Number of Interconnections?
Audience Poll #2

• What application would your company benefit most from using domain-specific accelerators?
  – AI and/or Machine Learning
  – Security
  – Edge computing
  – IoT
  – Storage/database acceleration
  – Other
What are the Technical and Business Challenges Related to Chiplets?

- Chiplet technology requires a different business model than that used for monolithic silicon IP

- HBM has been a business and technical proof point for multi-die integration
  - Multi-die test on a single laminate
  - Multi-party yield analysis/contributions
  - Thermal/mechanical modeling and reliability
  - Interface interoperability

- Production lifetimes and test are a key consideration
  - Commitments to production, backward compatibility of follow-on chiplets
  - Technical approaches can minimize impact of changes (Chip-Scale Packages, etc)
  - Standards-based approaches a must

Avera Semi HBM Integration
Near reticle size die
Example Business Model

- ASIC provider integrates multiple die or CSP on a substrate

- Sourcing from chiplet providers
  - Purchasing and/or consignment models need to be established by opportunity
  - Ideally standardized
Challenges Being Addressed in ODSA

- Where necessary, extensions to standards
- Adoption of appropriate open IPR licensing model
- Interface IP Agnostic Transaction Layer
- Chiplet-to-chiplet assembly and test
- Business models to enable chiplets
- Ecosystem of interface providers
- Ecosystem of chiplet providers
- Ecosystem of integrated ASIC providers
Democratize Advanced SoC Designs For Domain-Specific Accelerators: Call for Industry Collaboration

- The Open Domain-Specific Accelerator (ODSA) Workgroup is open to all companies wishing to participate
- Goal: any vendor’s silicon die as a building block that can be utilized in a chiplet-based SoC design
- Implementing open specifications contributed by participating companies
- Enable use of processors, accelerators, and memory and I/O peripherals using optimal process nodes
- Email us for more information: info@odsachiplets.org
ODSA Workshop – January 29, 2019

• Join us to learn how you can participate in ODSA as well as meet industry experts that are contributing to the workgroup:
  – Business issues the ODSA solves
  – Technical issues the ODSA solves
  – Plans to build a PoC with the ODSA architecture
  – What open source organization will the ODSA live?
  – What are steps moving forward?

For more information visit: https://netronome.regfox.com/odsa-workshop

• Location:
  GLOBALFOUNDRIES Headquarters
  2600 Great America Way, Santa Clara, CA
Questions and Answers?

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