SmartNICs to xPUs: Why is the Use of Accelerators Accelerating?

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Agenda

- What is an xPU?
- Trends and workloads
- Deployment and Solutions
- Market landscape
What is an xPU?

Dr Joseph L White, Fellow, Dell
xPU Terminology: Take xPU where ‘x’ stands for…

<table>
<thead>
<tr>
<th>xPU</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartNIC</td>
<td>SmartNIC (Intelligent NIC has also been used)</td>
</tr>
<tr>
<td>DPU</td>
<td>Data Processing Unit</td>
</tr>
<tr>
<td>IPU</td>
<td>Infrastructure Processing Unit</td>
</tr>
<tr>
<td>FAC</td>
<td>Function Accelerator Card</td>
</tr>
<tr>
<td>NAPU</td>
<td>Network Attached Processing Unit</td>
</tr>
<tr>
<td>NPU</td>
<td>Neural Processing Unit</td>
</tr>
<tr>
<td>TPU</td>
<td>Tensor Processing Unit</td>
</tr>
<tr>
<td>GPU</td>
<td>Graphics Processing Unit</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>NPU</td>
<td>Network Processing Unit</td>
</tr>
<tr>
<td>APU</td>
<td>Application Processing Unit (GPU + CPU)</td>
</tr>
</tbody>
</table>

These are the xPUs
We have new things to define!

- vector, matrix, and tensor processing accelerators
- These already have good definitions and semantics
- General purpose compute
- Networking

Devices with a tightly coupled combinations of CPU, xPU, GPU, etc. will exist. The taxonomy gets interesting at that point...
xPU Definition

xPU - x Processing Unit

Effectively a micro-server optimized for dataflow and packet processing providing accelerators, offload engines, & local services

- xPUs are (typically) a component in a host system but can be completely independent (e.g. Edge, JBOF, Gateway)
- Presents virtual functions to a host (looks like a NIC, GPU, etc)
- Presents network interfaces

Representative Functions and Use Cases

- NVMe-oF & Storage Offload
  - Optimize Solution Data-Flows (eg: access to GPUs & GPU pooling)
- Control Plane Offload (saves x86 Cores for business relevant work)
- Enhanced Security (Trust, Key Mgt, Encryption, Firewall, DPI)
- Improved Telemetry Generation and Analytics Capabilities
- Application Specific Computation Offload (RegEx, EBPF, containers)
- Physical and Virtual Networking and packet forwarding
- Network Gateway & SD-WAN
- Computational storage offloads
xPU Deployment

1. Servers

2. Gateways

3. Appliances
Trends & Workloads

Jai Menon
Chief Scientist, Fungible
xPUs/DPUs Address Two Important Data Center Trends

#1) **Growth of Data-Centric Tasks**  Stateful processing of multiple high b/w data streams for networking, storage, security, AI/ML (DPUs are optimized for data-centric tasks)

#2) **Cloudification of On-prem and Public Data Centers**  (xPUs/DPUs enable efficient disaggregation to improve TCO, power, footprint, agility, security of data centers (DPUs optimize data flow processing)
Examples of xPU-Based Products

**xPU enhances servers (2 examples)**

1A

**PCle Host Cards**
(offline storage, network, security)

Save cores & improve perf. (see next slide)

1B

**Disaggregated PCle/CXL device pools (e.g. GPUs)**

Enhanced disaggregation for cloudification

**Standalone xPU products (3 examples)**

2A

**High performance storage target**
10X speedup for storage targets

2B

**Computational storage**
20X speedup for some TPC-H queries

2C

**SDN appliance**
Overlay network processing @3X scale & 5X CPS
## Example Capabilities of xPU-Based Host cards (1A)

Accelerate performance and offload data-centric work from servers

<table>
<thead>
<tr>
<th>Domain</th>
<th>Sample Features</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>TCP, Network overlays, switching/routing (vRouter – e.g. save 7 cores, improve latency by 10X, throughput by 2X)</td>
<td>Offload and accelerate</td>
</tr>
<tr>
<td>Security</td>
<td>IPsec, SSL/TLS, kTLS, stateful firewall (NGFW – e.g. save 12 cores, improve perf by 6X)</td>
<td>Offload and accelerate</td>
</tr>
<tr>
<td>Storage</td>
<td>High speed NVMe/TCP offload DPUs are optimized for storage (Storage Initiator - e.g - save 96 cores, improve perf by 2X)</td>
<td>Offload and accelerate</td>
</tr>
<tr>
<td>Virtual PCIe Switch</td>
<td>GPU disaggregation</td>
<td>Efficient disaggregation</td>
</tr>
</tbody>
</table>
DPU-ENABLED HIGH PERFORMANCE STORAGE TARGET (2A)
SINGLE CHIP INTEGRATION IS THE FUTURE OF STORAGE PROCESSING

Typical CPU-Based Discrete Implementation

Example Implementation

<table>
<thead>
<tr>
<th>Attribute</th>
<th>x86 Based Discrete System</th>
<th>DPU Based Integrated System</th>
<th>Improvement Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance/W</td>
<td>9.2K IOPS/W</td>
<td>90.2K IOPS/W</td>
<td>10x</td>
</tr>
<tr>
<td>Performance</td>
<td>5M IOPS</td>
<td>13M IOPS</td>
<td>2.6x</td>
</tr>
<tr>
<td>Power</td>
<td>540 W</td>
<td>144 W</td>
<td>3.8x</td>
</tr>
</tbody>
</table>

High Performance, Low Power, Full Featured
xPU/DPU-Based Next Gen Data Center
Emerging approach to cloudification using composable disaggregated infrastructure (CDI)

3 key elements of the solution – xPU/DPU, low-overhead disaggregation, and composability

Standard x86 Servers w/xPU/DPU cards
Possibly Diskless, GPU-less

xPU/DPU offloads network, security, storage

xPU/DPU-based GPU Servers
Remote GPU pools with close to local performance

Standard IP Network

xPU/DPU-based Storage Servers
(Flash, Disk)

Remote storage pools with close to local performance

xPU/DPU-enabled low latency networking
Summary – Data centers will increasingly use CPUs, GPUs and xPUs

Data Centers will use

- xPUs/DPUs
  - To efficiently handle data-centric tasks (reduce power, TCO, footprint)

- Efficient disaggregation of expensive resources (reduce TCO, power, footprint)
  - xPU/DPU-based storage
  - xPU/DPU-based GPU/TPU pools
  - xPU/DPU-based host cards

- Composability software (agility, reduce # of SKUs)
  - To eliminate or reduce infrastructure silos
Deployment and Solutions

Lior Khermosh
NeuReality
Composable Infrastructure Deployment

- Generic Compute
- Storage
- Network
- Security
- GPUs
- Memory
- AI
CI Deployment <-> Disaggregation Options
What is an NAPU?

- An NAPU is a workflow-optimized hardware device that has the following attributes:
  - One or more specialized processing units
  - Native network capabilities
  - Streamlined hardware-based datapath
  - Virtualization capabilities
  - Managed resource abstraction layer
  - Self-sufficiency
xPU Solutions

- Different flavors of xPUs vary in their specific block diagram
xPU Functions

Service virtualization
Performance
Host Offloading
Storage Frontend
BM/VM/Container management
Server Root of Trust
P4 Programming
Compute Offload
Security Offload
Datapath Processor
Virtual Switch
NPU
Network QoS
Host NIC
Gateway

xPUs are an extremely effective way to Scale and handle Big Data
xPU Advantages

- **Host Offloading**
  - Compute cores dedicated to Application, not for infrastructure and datapath movement
  - In many cases the CPU is stalled, waiting for data from memory or IO

- **High Performance**
  - Removing bottlenecks
  - Accelerating key complex components
  - QoS, Network processing, Firewall
  - Programmable @ Performance, ex: P4

- **xPUs are the Joints of Composable Infrastructure**
  - Using the right accelerator at the right place, in exactly the right portion, for the right part of the workload
  - Multiple types – Storage, Accelerators
  - Native virtualization and datacenter management

- **Isolated embedded controlling entity**
  - Excellent for Server Management and Security
  - Bare Metal/VMs management, RoT
Market Landscape

John Kim
NVIDIA
xPUs Sales to Grow Rapidly but not Dominate NICs

- By 2023, one in three NICs sold will be a FAC\(^1\) – Gartner\(^\circledR\)
  - By 2026, SmartNIC revenue will reach $1.6 Billion – Dell’Oro\(^2\)
  - By 2026, more than half the servers shipped to hyperscaler CSPs will be equipped with SmartNICs – Dell’Oro\(^2\)

- Not all accelerator cards included in FAC/SmartNIC forecasts
  - i.e. CPU, TPU, GPU, APU or crypto card not counted as SmartNICs

- Managed appliances will drive additional xPU sales – not yet considered by most analysts

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\(^1\)Source: Gartner “Your Server is Eating Your Network – Time to Rethink Data Center Network Architectures,” Gartner, G00742770 – April 2021

\(^2\)Source: Dell’Oro Group “Ethernet Adapter & Smart NIC 5-Year Forecast Report” – February 2022

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xPU Vendors and Routes to Market

Who Makes xPUs

- Startups
  - Will they be absorbed?
- Big Vendors
  - Silicon vendors (AMD/Xilinx, Intel, Marvel, NVIDIA, etc.)
  - Networking vendors
- CSPs – design/codesign

Who Sells xPUs?

- xPU vendors
- Infrastructure OEMs and ODMs
- VARs, SIs
- Cloud SPs – indirectly
How Do We Program xPUs?

- Standard open interfaces to specific functions
  - E.g. DPDK, SPDK, OVS/OVN, NVMe-oF, P4

- Vendor-specific development platforms and SDKs
  - Some xPU functions work across most xPUs; others are vendor/card-specific
  - High-level and low-level programming interfaces

- Development of open platforms/SDKs
  - OPI Project and IPDK
  - DASH

- Programmers: vendor, end-user, ISV, infrastructure OEM, SI, or CSP
Tradeoffs and Considerations for Deploying xPUs

Yes, xPU in Every Server!
- Offloads infrastructure tasks
- Frees server CPU for apps
- Higher efficiency, lower TCO, flexible disaggregation
- Can improve security

No, Only in Some Servers
- Increases server CapEx
- Offloads specific workloads
- Higher power consumption
- Needs to be programmed; no one standard interface
Summary

- We’ve covered…
  - What is an xPU?
  - Trends and workloads
  - Deployment and Solutions
  - Market landscape
- This is a Series!
  - Join us for our next webcast:

xPU Accelerator Offload Functions
June 29, 2022
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