# Introduction to QorIQ T Series: Scalable SoCs Designed to Meet Today's Demanding System Performance Requirements in Multiple Vertical Markets

Jeffrey Ho
Business Development

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Networking Evolution

Proprietary Hardware & Software	Compute Based Windows OS	Standards Based Hardware & Software/Open Source
Host Era	**PC Era**	**Internet of Things**
1960 - 1985	1985-2006	2006 - 2025

Connectivity Fuels Growth in MPU

50B Connected Nodes by 2020*

*Source Ericsson

Networked Infrastructure: $3.5B SAM

1 Cloud

2 Wireless

3 Enterprise

Networked Everything: $1B SAM

1 Factory Automation

2 Smart Energy

3 Transportation

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The Trends and Their Impact

The Growing Data Tsunami

Trend	Impact
• Billions of devices • Growth in mobility • Bigger networking pipes • Intelligent edge / services	• Higher performance packet processing • High speed interfaces: 10G – 40G – 100G • Deep packet inspection – traffic management (specialized acceleration engines) • Integrated security processing • Many core architecture, tiled arch with chip-chip interconnect as intermediate step
• Elastic resource, services • Specialized server architectures • Security continues to become more critical	• New applications: ADC – application delivery controller; WAN optimization; bulk security/comp • Convergence: Growth of SAN, FCoE, adapters • Server specialization – microservers • Virtualization of resources (compute, networking, storage) & performance/watt focus • More services enabled in remote routers: More complexity and performance

Touchpad
Appliance
Cloud Networking
Mobile
GPS
Notebook
Home Entertainment

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QorIQ Communications Processor Roadmap

SDKs — Biannual releases: SDK 1.3 · SDK 1.4 · SDK 1.5 · SDK 1.6 · SDK 1.7

High Performance
- T4240
- P5040
- P5021
- P5020/10
- T4160
- P4080/40
- LS3xxx

Mid Performance
- T2080
- P3041
- P2041/40
- T2081
- MPC8569
- P2020/10
- LS2xxx

Value Performance
- T1040/42
- P1023/17
- T1020/22
- P1022/13
- P1021/12
- LS1xxx
- P1020//11
- LS1 Family
- P1010/14

Timeline: Existing | 4Q | 1Q 2Q 3Q 4Q 2012 | 1Q 2Q 3Q 4Q 2013 | 1Q 2Q 2014 | Next generation

Production / Sample

Legend: Production · Execution · Planning · Proposal

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New in 2013

Efficient Public Key Processor Portfolio

- C293
- C292
- C291

Breakthrough Security Acceleration
- Public key co-processor
- Scalable performance and power
- Leading performance/Watt/$

QorIQ T-Series

- T4240
- T4160
- T2081
- T2080
- T1040
- T1042

Mixed control and data plane processing
- Up to 1.8 GHz; high amount of off-load
- Highly-parallelized workloads
- 48 Gbps IP forwarding
- Emerging network services requirements

Optimal performance to power ratio
- Up to 1.8 GHz
- Achieving less than 6W
- Broadest portfolio of power-efficient pin compatible SoCs

Strong execution	Portfolio extension	Focus on power dissipation	Focus on energy management

Freescale C29x Family of Crypto Coprocessors

- Breakthrough performance per dollar

- Expanding Freescale's footprint into the data center

- Leveraging 30 years of R&D in security

C29x Family Overview
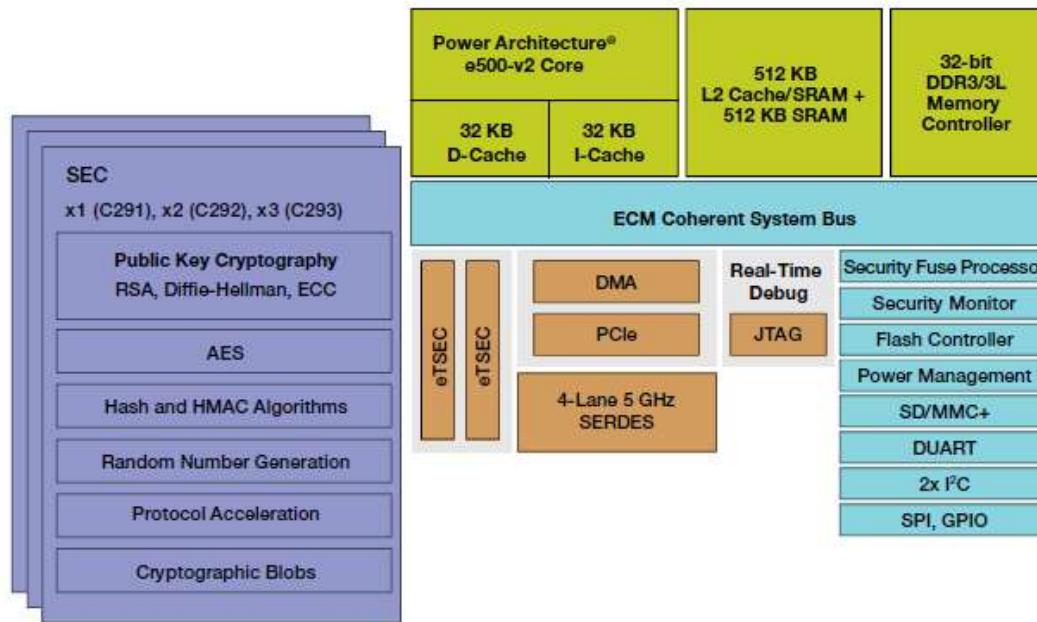
	C291	C292	C293
Security Engines	1	2	3
Typical Power (65C)	~4W	~6W	~10W
2048 bit RSA KOPS/sec	8	18	32

Block diagram labels:

- Power Architecture® e500-v2 Core
- 32 KB D-Cache
- 32 KB I-Cache
- 512 KB L2 Cache/SRAM + 512 KB SRAM
- 32-bit DDR3/3L Memory Controller
- ECM Coherent System Bus
- SEC x1 (C291), x2 (C292), x3 (C293)
  - Public Key Cryptography RSA, Diffie-Hellman, ECC
  - AES
  - Hash and HMAC Algorithms
  - Random Number Generation
  - Protocol Acceleration
  - Cryptographic Blobs
- eTSEC
- DMA
- PCIe
- 4-Lane 5 GHz SERDES
- Real-Time Debug
- JTAG
- Security Fuse Processor
- Security Monitor
- Flash Controller
- Power Management
- SD/MMC+
- DUART
- 2x I²C
- SPI, GPIO

- **PCIe based public key accelerator with scalable performance and power**
- **Optimized for public key offload**
  - Leading performance/dollar
  - Lower power
- **Trust architecture to enable secure key management**

Breakthrough performance per dollar:

- **PCIe comparison**:
  - x4 C293 PCIe card:

  - >120k RSA2048 Ops/Sec

  - Costs less than single chip PCIe offering from competition and offers 3-4x performance

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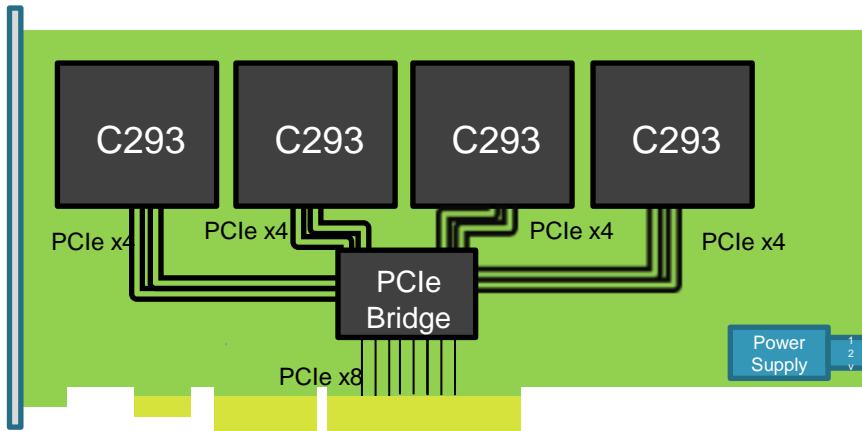
C29x Flexible Use Cases
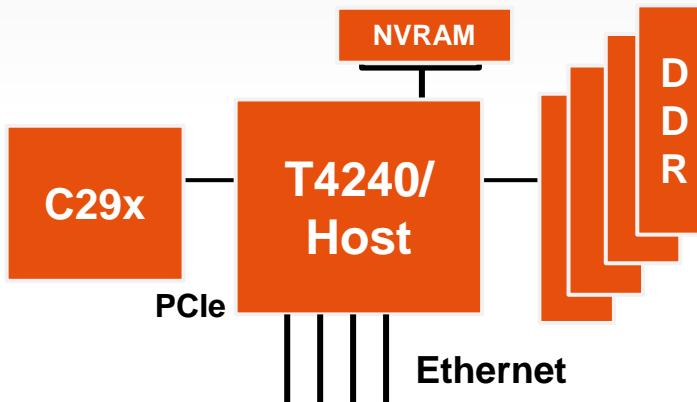
Public Key (PK) Calculator

- PCIe look-aside coprocessor
- No external memory required
- SW: host driver + C29x firmware
- Applications:
  - Application delivery controllers
  - Security appliances

Secure Key Management Module (SKMM)

- Trust architecture protects secure key
  - Secure boot, key storage, key encryption
- PCIe look-aside coprocessor
- SW: host driver (optional) + C29x running SDK
- Applications:
  - Hardware security modules
  - Critical access security appliances
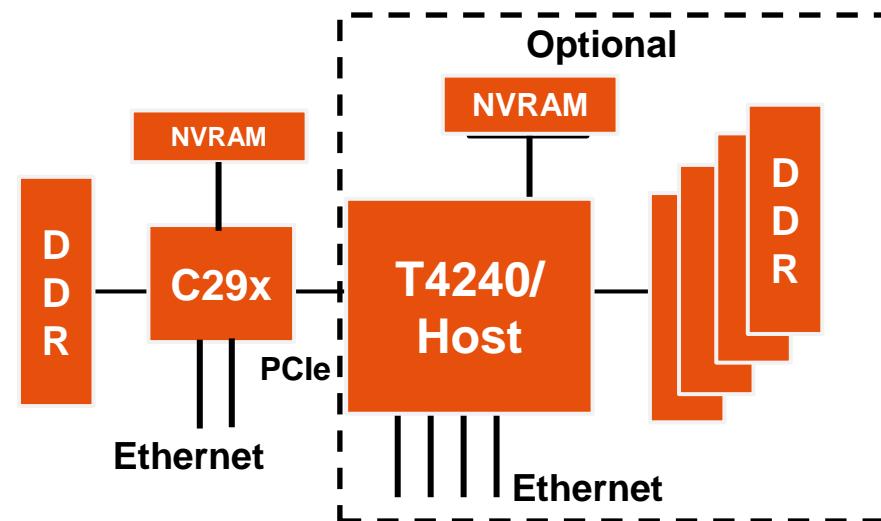
C29x Family Software

- **C29x crypto coprocessor:**
  - Public key firmware (PK use case)
  - Linux SDK with support for PK offload
    (SKMM use case)

- **Host processor (QorIQ, x86):**
  - Linux®
  - Enhanced OpenSSL Library
  - Crypto acceleration framework based on open source crypto dev
  - C29x coprocessor driver
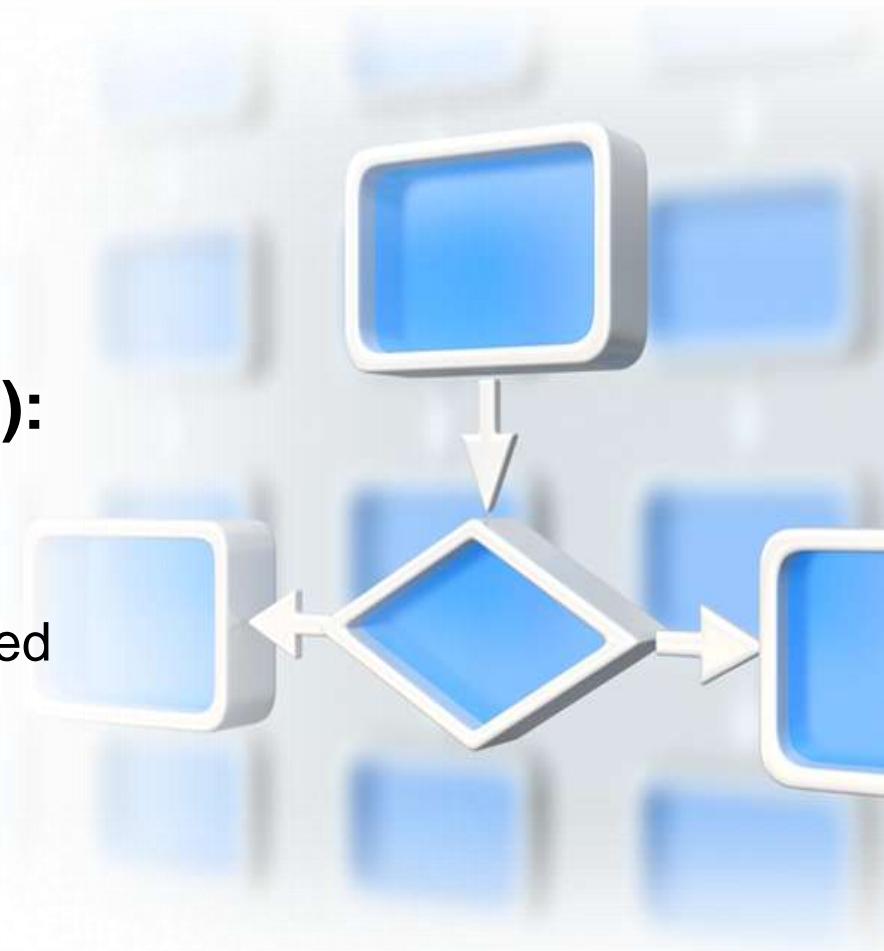
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Summary: Freescale C29x Family of Crypto Coprocessors

- Secure network traffic is growing…fast!

- Security is everywhere and must scale – hardware acceleration is key to this

- Freescale C29x family of crypto coprocessors

  - Breakthrough performance per dollar – with scalable power & performance

  - Expands Freescale's footprint in the data center and network security appliances

  - Leveraging 30 year investment in security R&D

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The High-End—Driving the Cloud…

NEW

NEW

Control Plane Focus

QorIQ – P5
P5040 / P5021

QorIQ -T4
T4240
T4160

QorIQ – P5
P5020 / P5010

QorIQ – P4
P4080
P4040
P4081

Network Services
Control & Data Plane

e600 +Soc

Maximum Transactions Core-to-memory & Packet processing

Performance & Software Focus

Increasing Performance
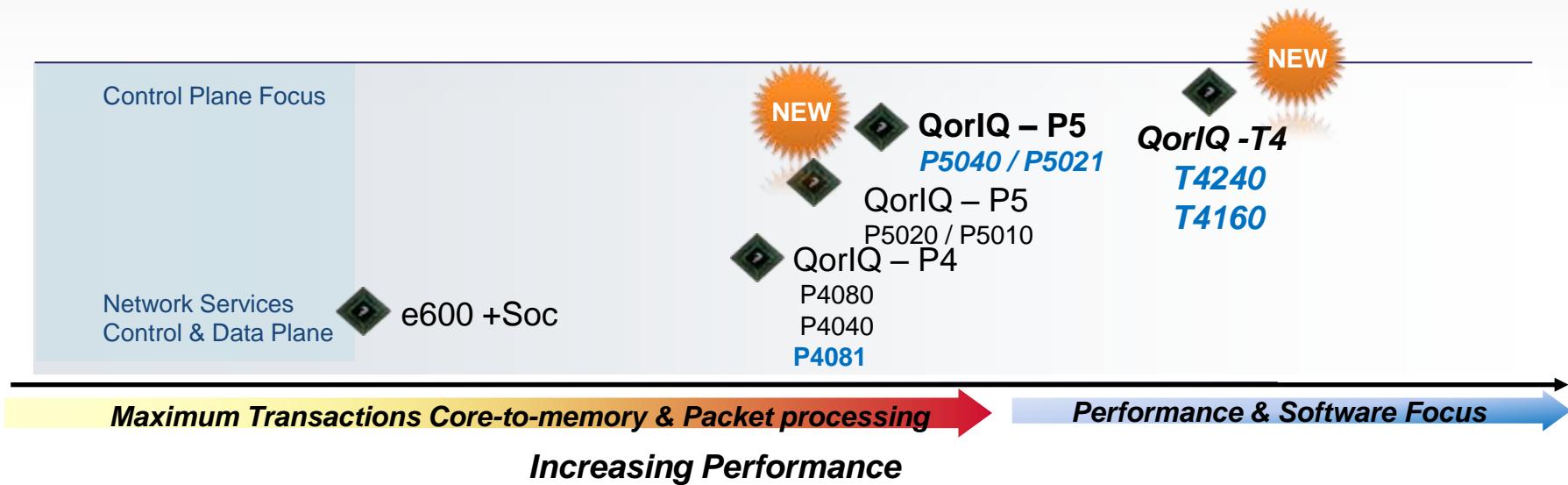
Service Provider	Datacenter
Core/ Edge Routing Aggregation Transport	WAN Optimization ADC/SLB Monitoring

Sampled the First QorIQ T-Series SoC Solution

- The new QorIQ T-Series T4240 and T4160
  - Extending Freescale's leadership in communications processors
  - Enables new applications in emerging Cloud Networking

- Advanced Features
  - Supporting up to 24-logical cores in 3 (T4240) or 2 (T4160) clusters
  - Industry's highest CoreMark score and best CoreMark per Watt
  - 64-bit Power Architecture® core with Dual Strong Threads
  - Low latency and large memory space
    - 40-bit real address space with Terabyte physical address
  - Advanced networking with 50Gbps PCD; 10GHz SERDES; large number of accelerators
  - Energy Efficiency: 1.4 to 3x more power efficient than competition

T4240

T4160

BUILT ON

Power

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QorIQ T4240 Target Markets, Key Features

Enterprise / Service Provider Equipment

Fabric Controller

Storage Networks

Aerospace & Defense

The T4240 and T4160 Processors are architected to provide Best in Class performance within an embedded power envelope

Balanced Architecture

- High-performance dual threaded 64b cores
- Multicores up to 1.8GHz with 128b AltiVec
- Power Efficiency
- 4x performance of P4080 App Accelerators
- **CoreNet On-chip Fabric**
- Designed to efficiently "feed" the cores
- Eliminates bus contention

High Speed Interconnect

- Next gen PCIe, Multiple XAUI, Interlaken LA SATA, Aurora

Tightly Coupled Cache Hierarchy

- Optimum banked and tiered memory architecture
- Cores are closer to the data to reduce latency

High Performance Virtualization

- Advanced Core and SoC
- Software solutions designed for T4xxx

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T4240 Block Diagram

Processor
- 12x e6500, 64b, up to 1.8GHz
- Dual threaded, with128b AltiVec
- Arranged as 3 clusters of 4 CPUs, with 2MB L2 per cluster; 256KB per thread

Memory SubSystem
- 1.5MB CoreNet Platform Cache w/ECC
- 3x DDR3 Controllers up to 1.8GHz
- Each with up to 1TB addressability (40 bit physical addressing)

CoreNet Switch Fabric

High Speed Serial IO
- 4 PCIe Controllers, with Gen3
  - SR-IOV support
- 2 sRIO Controllers
  - Type 9 and 11 messaging
  - Interworking to DPAA via Rman
- 1 Interlaken Look-Aside at up to10GHz
- 2 SATA 2.0 3Gb/s
- 2 USB 2.0 with PHY

Network IO
- 2 Frame Managers, each with:
  - Up to 25Gbps parse/classify/distribute
  - 2x10GE, 6x1GE
  - HiGig, Data Center Bridging Support
  - SGMII, QSGMII, XAUI, XFI

Datapath Acceleration
- **SEC**- crypto acceleration 40Gbps
- **PME-** Reg-ex Pattern Matcher 10Gbps
- **DCE-** Data Compression Engine 20Gbps

Sampling NOW

The Mid-Tier Products….

Power Constrained Highest Performance Control plane

Mixed Control & Data plane

PowerQUICC III

PowerQUICC II Pro

QorIQ – P3
P3041

QorIQ – P2
P2020/P2010
P2040/P2041

NEW

T2080

Maximum Transactions Core-to-memory & Packet processing

Performance & Software Focus

Increasing Performance

Storage

NAS

Enterprise

UTM

SBC

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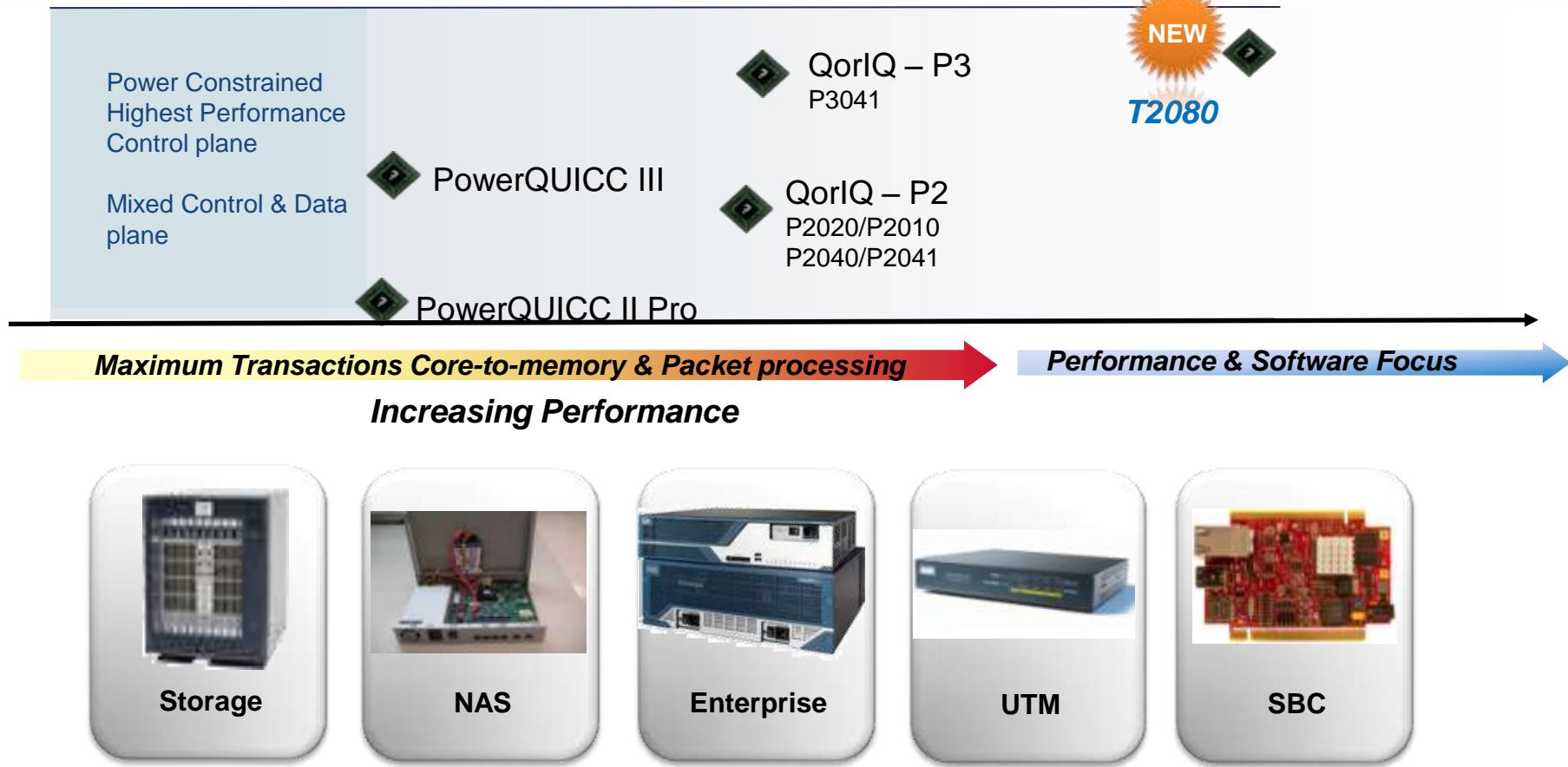
The Industry Leading Low-Power Value Tier

Power Sensitive Applications 3W - 5W – 9W		

PowerQUICC II

PowerQUICC I

QorIQ – P1
P1010/P1014
P1020/P1011/P1024/P1015
P1021/P1012/P1025/P1016
P1022/P1013
P1023/P1017

T1040
T1042
T1020
T1022

Maximum Transactions Core-to-memory & Packet processing

Performance & Software Focus

Increasing Performance

Media Streaming

NVR

Factory Automation
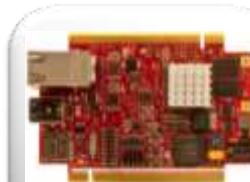
General Purpose

WLAN AP

VPN Router

Extending the QorIQ T-Series SoC Solution

- The new QorIQ T-Series T1040/20/42/22 and T2081
  - Industry's most scalable, pin-compatible family of devices with a common architecture
  - Upgrade to higher performance as needed, 2x-4x the performance over QorIQ P1/P2 family devices
- Advanced Features
  - Advanced integration with multilayer Gigabit Ethernet switch to reduce system cost and design complexity
  - Offload engines – encryption/decryption for high performance security
  - Deep packet inspection offload engine enabling UTM services
  - Data path acceleration architecture (DPAA) – for QoS and balanced networking performance
  - Continued support for HDLC, TDM, ISDN interfaces natively
  - Virtualization to support customers and 3rd party software
  - Highest performance CPU cores within a power envelope
  - Small form factor, fanless and convection-cooled designs
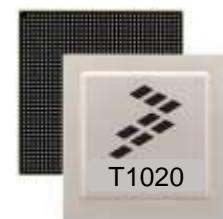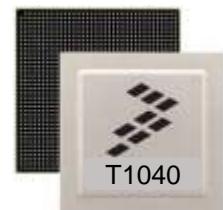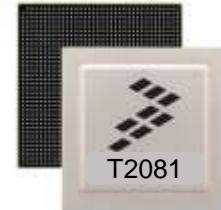
QorIQ T1 Target Markets, Key Features

Enterprise Routers/Switches

Industrial Computing and Networking

UTM Security Appliances

Management & Control

The T1 communications processors are architected to provide maximum performance per watt

- Highest performance CPU cores within a power envelope

- Advanced integration with multilayer Gigabit Ethernet switch to reduce system cost and design complexity

- Offload engines – encryption/decryption for high performance security

- Deep packet inspection offload engine enabling UTM services

- Data path acceleration architecture (DPAA) – for QoS and balanced networking performance

- Virtualization to support customers and 3rd party software

- Small form factor, fanless and convection-cooled designs

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One of the Industry's Most Scalable, Pin-Compatible Communications Processor Family

Performance / Power

- **T2081** — Eight Virtual Cores up to 1.8GHz
- **T1040** — Quad-Core up to 1.4GHz; Integrated GbE Switch
- **T1042** — Quad-Core up to 1.4GHz
- **T1020** — Dual-Core up to 1.4GHz; Integrated GbE Switch
- **T1022** — Dual-Core up to 1.4GHz

Scale from dual, quad to eight virtual cores with QorIQ T1/T2 devices

T1040 Block Diagram

256 KB Backside L2 Cache

Power Architecture® e5500

32 KB D-Cache

32 KB I-Cache

256KB Platform Cache

32/64-bit DDR3L/4 Memory Controller

Security Fuse Processor
Security Monitor
16b IFC
Power Management
SD/MMC+
2x DUART
2x I2C
SPI, GPIO
2x USB 2.0 w/PHY
DIU

Cygnus™ Coherency Fabric

PAMU PAMU PAMU PAMU — Peripheral Access Mgmt Unit

Security 5.4 (XoR, CRC)
Queue Mgr.
Parse, Classify, Distribute
1G 1G 1G 1G
4xDMA
QUICC Engine
Real Time Debug
Watchpoint Cross Trigger

Pattern Match Engine 2.0
Buffer Mgr.
8 Port Switch
1G 1G 1G 1G
1G 1G 1G 1G
PCIe PCIe PCIe PCIe
SATA 2.0 SATA 2.0
TDM/HDLC TDM/HDLC
Perf Monitor
CoreNet Trace
Aurora

8-Lane 5GHz SERDES

Processor
- 4x e5500, 64b, up to 1.4GHz
- Each with 256KB backside L2 cache
- 256KB Shared Platform Cache w/ECC
- Supports up to 64GB addressability (36 bit physical addressing)

Memory SubSystem
- 32/64b DDR3L/4 Controller up to 1333MHz

Cygnus Switch Fabric

High Speed Serial IO
- 4x PCIe Gen2 Controllers
- 2x SATA 2.0, 3Gb/s
- 2x USB 2.0 with PHY

Network IO
- FMan packet Parse/Classify/Distribute
- Lossless Flow Control, IEEE 1588
- 3x 10/100/1000 Ethernet Controllers
- **8-Port Gigabit Ethernet Switch**
- QUICC Engine
    - HDLC, 2x TDM
- **Green Energy Operation**
- Fanless operation quad-core 1.2GHz
- Packet lossless deepsleep
    - Programmable wake-on-packet
    - Wake-on-timer/GPIO/USB/IRQ

Power targets
- Enable Convection cooled system design

Datapath Acceleration
- SEC- crypto acceleration
- PME- Reg-ex Pattern Matcher

T10xx family of pin-compatible processors

T1040

Device
- 28HPM Process
- 780-pin 3-2-3 C4 FC package
- 23x23mm, 0.8mm pitch

Datapath Acceleration
- SEC- crypto acceleration
- PME- Reg-ex Pattern Matcher

T1042

Processor
- 4x e5500, 64b, up to 1.4GHz
- Each with 256KB backside L2 cache
- 256KB Shared Platform Cache w/ECC
- Supports up to 64GB addressability (36 bit physical addressing)

Memory SubSystem
- 32/64b DDR3L/4 Controller up to 1333MHz

Cygnus Switch Fabric

High Speed Serial IO
- 4x PCIe Gen2 Controllers
- 2x SATA 2.0, 3Gb/s
- 2x USB 2.0 with PHY

Network IO
- FMan packet Parse/Classify/Distribute
- Lossless Flow Control, IEEE 1588
- 5x 10/100/1000 Ethernet Controllers
- QUICC Engine
  - HDLC, 2x TDM

Green Energy Operation
- Fanless operation quad-core 1.2GHz
- Packet lossless deepsleep
  - Programmable wake-on-packet
  - Wake-on-timer/GPIO/USB/IRQ

Datapath Acceleration
- SEC- crypto acceleration
- PME- Reg-ex Pattern Matcher

Center specifications (T1040)

Processor
- 4x e5500, 64b, up to 1.4GHz
- Each with 256KB backside L2 cache
- 256KB Shared Platform Cache w/ECC
- Supports up to 64GB addressability (36 bit physical addressing)

Memory SubSystem
- 32/64b DDR3L/4 Controller up to 1333MHz

Cygnus Switch Fabric

High Speed Serial IO
- 4x PCIe Gen2 Controllers
- 2x SATA 2.0, 3Gb/s
- 2x USB 2.0 with PHY

Network IO
- FMan packet Parse/Classify/Distribute
- Lossless Flow Control, IEEE 1588
- 3x 10/100/1000 Ethernet Controllers
- **8-Port Gigabit Ethernet Switch**
- QUICC Engine
  - HDLC, 2x TDM

Processor	Number of cores	L2 switch
T1020	2	8-port
T1022	2	No
T1040	4	8-port
T1042	4	No

T1020

Device
- 28HPM Process
- 780-pin LCFC package
- 23x23mm, 0.8mm pitch

Datapath Acceleration
- SEC- crypto acceleration
- PME- Reg-ex Pattern Matcher

Center specifications (T1020)

- bit physical addressing)

Memory SubSystem
- 32/64b DDR3L/4 Controller up to 1333MHz

Cygnus Switch Fabric

High Speed Serial IO
- 4 PCIe Gen2 Controllers
- SATA 2.0, 3Gb/s
- 2 USB 2.0 with PHY

Network IO
- FMan packet Parse/Classify/Distribute
- Lossless Flow Control, IEEE 1588
- 3x 10/100/1000 Ethernet Controllers
- **8-Port Gigabit Ethernet Switch**
- QUICC Engine
  - HDLC, 2x TDM

Green Energy Operation
- Fanless operation quad-core 1.2GHz
- Packet lossless deepsleep
  - Programmable wake-on-packet
  - Wake-on-timer/GPIO/USB/IRQ

T1022

Processor
- 2x e5500, 64b, up to 1.4GHz
- Each with 256KB backside L2 cache
- 256KB Shared Platform Cache w/ECC
- Supports up to 64GB addressability (36 bit physical addressing)

Memory SubSystem
- 32/64b DDR3L/4 Controller up to 1333MHz

Cygnus Switch Fabric

High Speed Serial IO
- 4 PCIe Gen2 Controllers
- SATA 2.0, 3Gb/s
- 2 USB 2.0 with PHY

Network IO
- FMan packet Parse/Classify/Distribute
- Lossless Flow Control, IEEE 1588
- 5x 10/100/1000 Ethernet Controllers
- QUICC Engine
  - HDLC, 2x TDM

Green Energy Operation
- Fanless operation quad-core 1.2GHz
- Packet lossless deepsleep
  - Programmable wake-on-packet
  - Wake-on-timer/GPIO/USB/IRQ

Device
- 28HPM Process
- 780-pin LCFC package
- 23x23mm, 0.8mm pitch

Datapath Acceleration
- SEC- crypto acceleration
- PME- Reg-ex Pattern Matcher

T2080

Processor
- 4x e6500, 64b, 1.2 - 1.8GHz
- Dual threaded, with 128b AltiVec
- 2MB shared L2; 256KB per thread

Memory Subsystem
- 512KB Platform Cache w/ECC
- 1x DDR3/3L Controllers up to 1.8GHz
- Up to 1TB addressability (40 bit physical addressing)

Switch Fabric

High Speed Serial IO
- 4 PCIe Controllers, one at Gen3 three at Gen2
  - 1 with SR-IOV support
  - x8 Gen2
- 2 sRIO Controller
  - Type 9 and 11 messaging
  - Interworking to DPAA via RMan
- 2 SATA 2.0 3Gb/s
- 2 USB 2.0 with PHY

Network IO
- Up to 25Gbps Simple PCD each direction
  - 4x1/10GE, 4x1GE or 2.5Gb/s SGMII
  - XFI, 10GBase-KR, XAUI, HiGig, HiGig+, SGMII, RGMII, 1000Base-KX
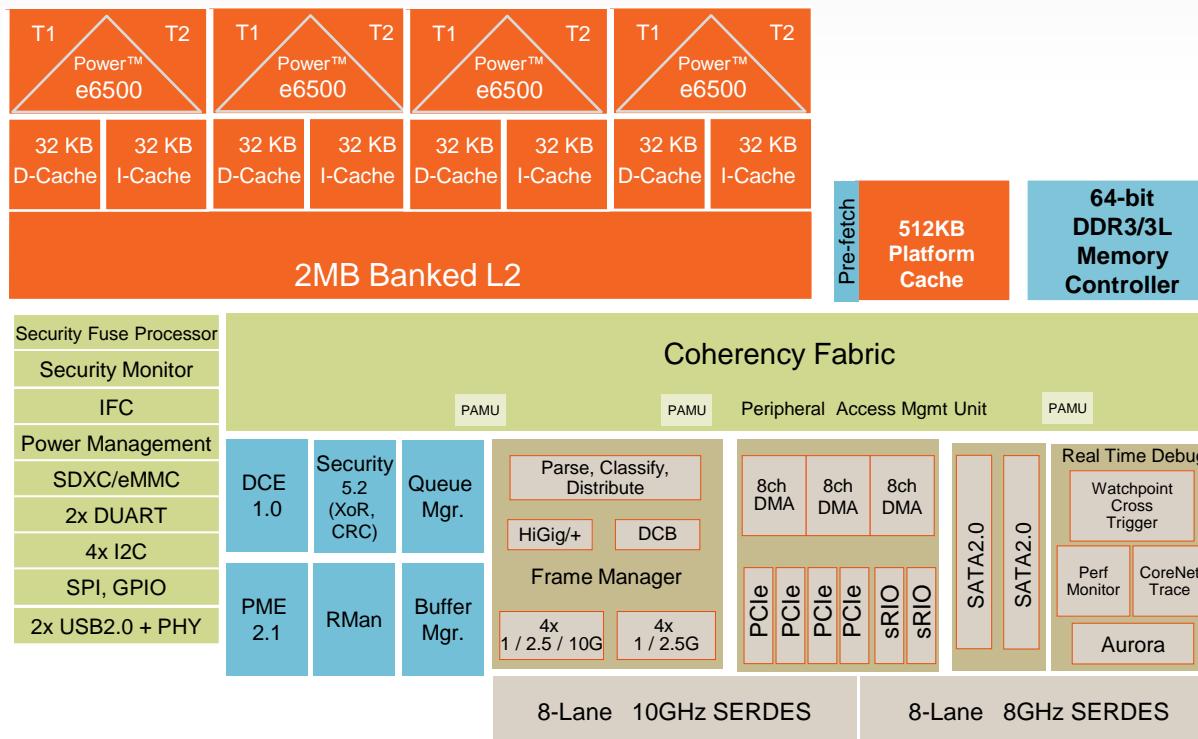
Datapath Acceleration
- **SEC** - crypto acceleration 10Gbps
- **DCE** - Data Compression Engine 17.5Gbps
- **PME** – Pattern Matching Engine to 10Gbps

T2081: Pin-Compatible Migration from T1 Family
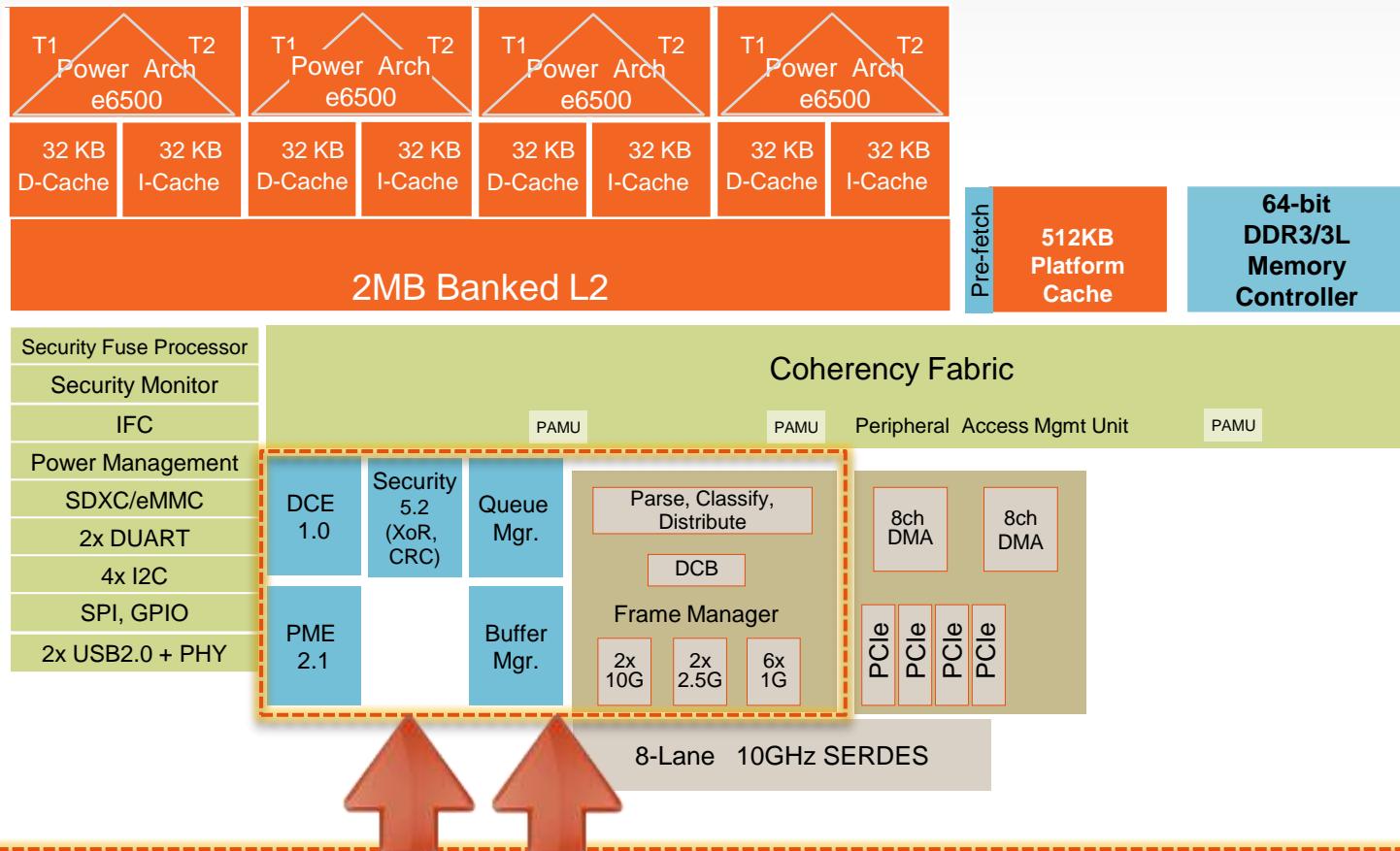
Migration Path to T Series from P series
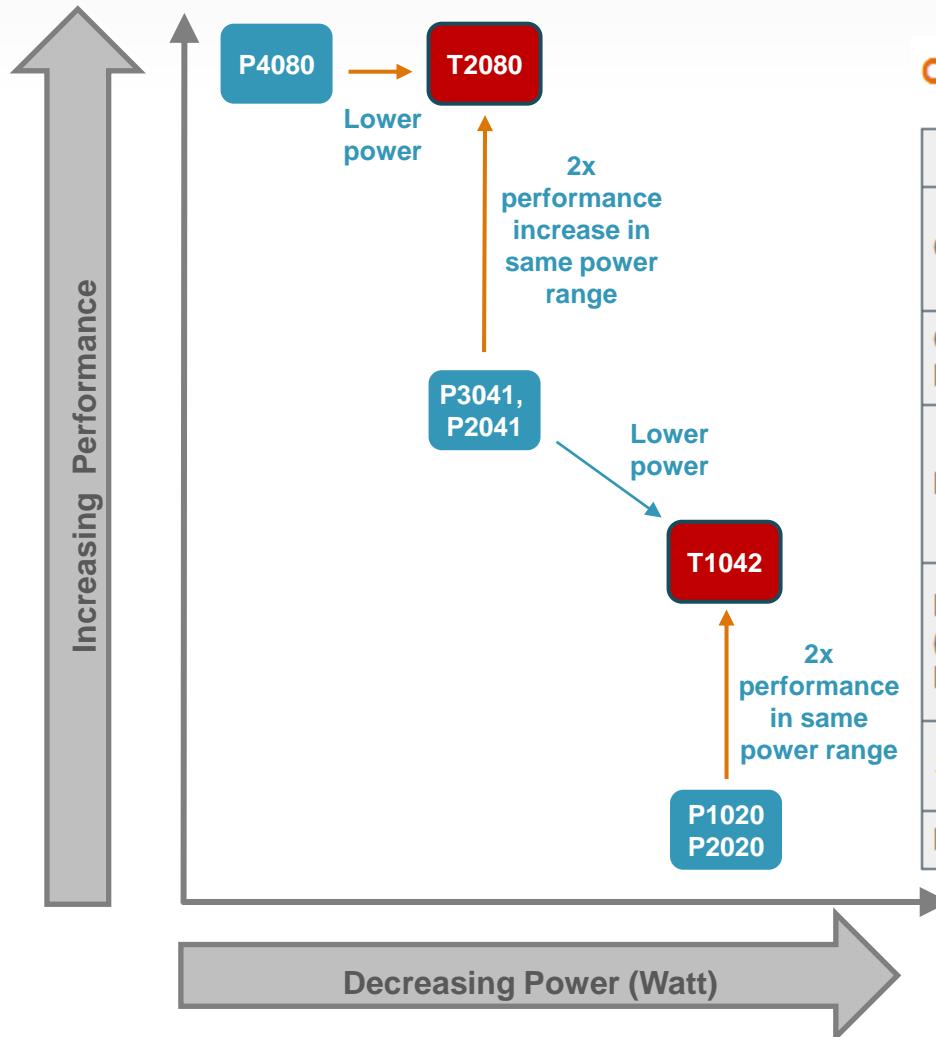
Comparison Table

	T1020	T1022	T1040	T1042	T2081
CPU	2 e5500	2 e5500	4 e5500	4 e5500	4 e6500 (dual-threaded)
Core Frequency	1200-1400MHz	1200-1400MHz	1200-1400MHz	1200-1400MHz	1500-1800MHz
DDR I/F	1x DDR3L/4 to 1333MT/s	1x DDR3L/4 to 1333MT/s	1x DDR3L/4 to 1333MT/s	1x DDR3L/4 to 1333MT/s	1x DDR3/3L to 2133MT/s
Ethernet (with IEEE1588v2)	8-Port GE Switch + 4x 1GE	5x 1GE	8-Port GE Switch + 4x 1GE	5x 1GE	2x 1/10GE + 6x 1GE
SERDES	8 lanes (5GHz)	8 lanes (5GHz)	8 lanes (5GHz)	8 lanes (5GHz)	8 lanes (10GHz)
Package	Pin Compatible				

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Networking SoC Reference Software Architecture

Freescale Linux SDK

Guest Linux Instance

NCSW Bare Board

NSCW Apps

NCSW USDPAA Driver

Std Linux App

Std Linux Control

ASF Apps

USDPAA

USDPAA Apps

| Linux Apps | Vortiqa Apps | Cust Apps | Demo Apps |

QEMU

User Space

Std Linux APIs (pthreads, sockets, hugetlbfs, scheduler, etc.)

system call interface

KVM

Device Manager I/F

NCSW Kernel Library

Kernel Modules

NCSW OS Wrappers

Linux Net Stack

ASF Control

Zero Copy Socket

NCSW Bare Board Wrappers

ASF (Fast Path)

Kernel Drivers

| RMAN | SEC | FMAN | BMAN | QMAN | PME |

USDPAA Drivers

| RMAN | SEC | FMAN | BMAN | QMAN | PME |

Kernel Space

NCSW Low Level Drivers

Firmware Acceleration

| Microcode | DPAA Accel. |

MMU

PAMU

FSL Embedded Hypervisor (Optional)

| Accel (Non-DPAA) | QE/uQE | DPAA | e500v2 | e500dp | e500mc | e5500 | e6500 | ARM |

Community developed Software

FSL developed Software

Customer/Partner developed Software

SOC Functional Block

FSL Software Architectures for QorIQ - Evolution
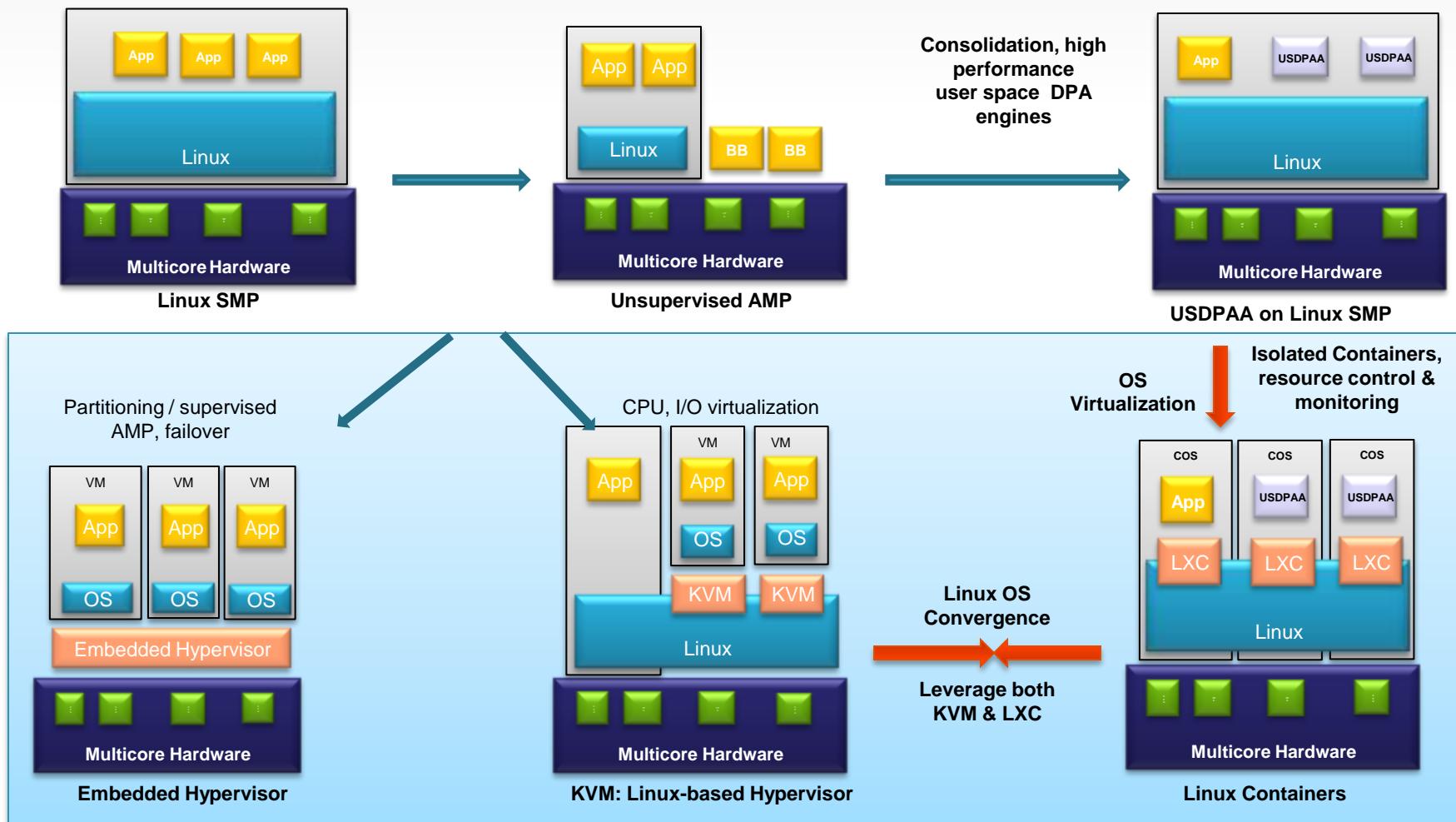
Freescale's KVM implementation takes advantage of our core's tri level protection scheme to ensure high performance KVM solution

Freescale Accelerating Time to Market

WLAN EAP

Security Appliance

Factory Automation

SmartNIC

Multiservice Gateway

Right Partners

Right Platforms (Eval systems, Ref Designs)

Accelerated Time to Market

Turnkey SW (VortiQa and others)

Best Processors (QorIQ Chip)
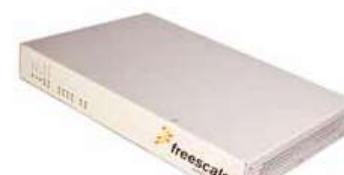
freescale™

Investing Heavily in Tools

Online Selector Tool

www.freescalewiki.com

Beyond Bits

New friendly development tools

Power on Tower

| PX-Series |
| PowerQUICC |
| QorIQ |
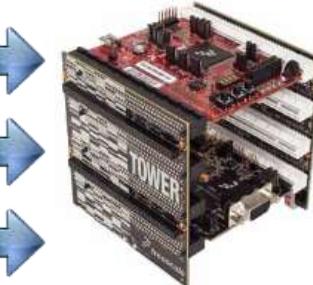
MQX Operating System
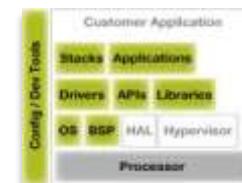
QorIQ Configuration & Optimization Suites

Tools Example:
T4240 Enablement for Fast Time to Market

General Purpose Dev Systems

T4240 QDS
- Full features development
- Evaluation
- Development

General
Purpose Development
System

T4240 RDB
- Low cost 1U development platform
- Evaluation
- Development

Enterprise and
Datacenter Appliance

System Solutions Development Systems

T4240 PCIe
- Host data path
- Evaluation
- Development
- Production

Datacenter

Coming soon!

freescale™

System Level Demos and Reference Solutions

Baseline Enablement

Fast Time to Market

Software

| Applications (VortiQa and Open Source Apps) |
| OS, CodeWarrior, Tools, BSP |

| Applications (VortiQa and Open Source Apps) |
| OS, CodeWarrior, Tools, Optimized BSP |

| App Framework (CODECS, …) |
| OS, CodeWarrior, Tools, Optimized BSP |

| Applications (VortiQa and Open Source Apps) |
| App Framework |
| OS, CodeWarrior, Tools, Optimized BSP |

Dev Systems

SOCs

Demos

Reference Solutions

Horizontal Offering - Focus on SoC

Vertical Offering - Focus on System Level

Traditional Data Center Architecture

Management

Servers
- Compute Functions
- Networking Functions

Storage

3 tier Switching

Load Balancing

Security

Evolved Data Center Architecture

Management & Orchestration

Data Center Ethernet Switch Based Fabric

Servers

Storage

Network Services

Security

WAN Optimization

ADC/SLB

Monitoring
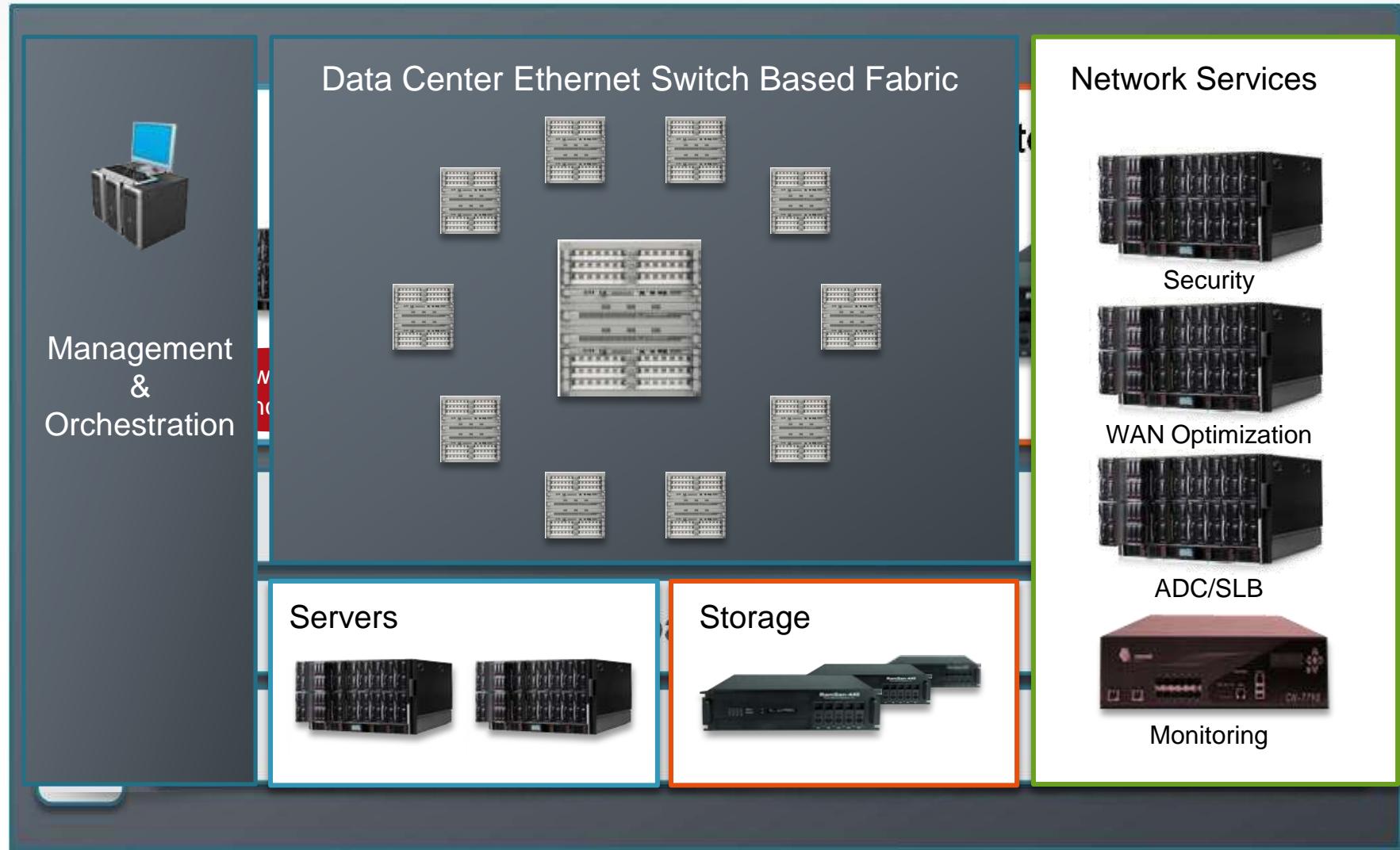
Freescale in the Data Center

- Freescale has a broad range of successful engagements with customers in the data center market

- Leveraging the broad Power-architecture based PowerQUICC and QorIQ portfolio and addressing multiple applications
  - ToR/ EoR Data Center Switches
  - SAN Switching, Bridging, Management
  - WAN Optimizations, ADC, Firewall/Security
  - Server controllers / management processors

Multicore Processors in NG Data Center and Networking Applications

- Data centers focused on reducing power and cost

- Network node consolidation driving multiple functions into fewer platforms

- Integrated service routers adding appliance capabilities

- Management of multiple devices is difficult and time consuming

Virtualization

Convergence

Increased bandwidth

10G adoption trends

CY10 CY11 CY12 CY13 CY14

freescale™
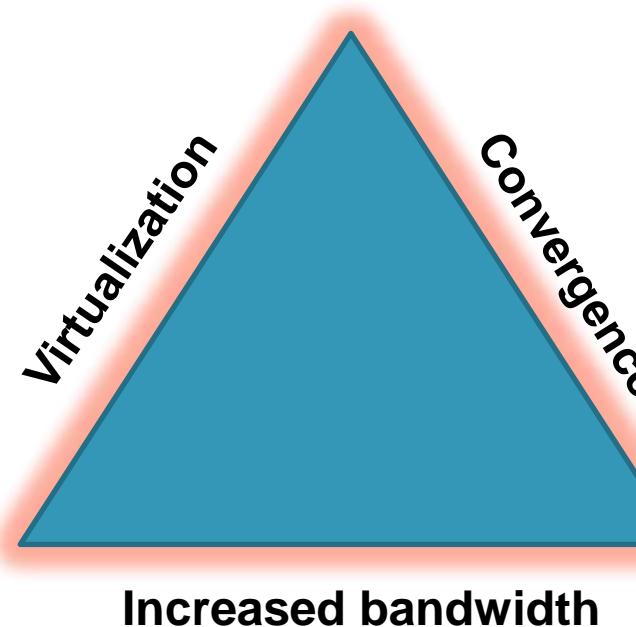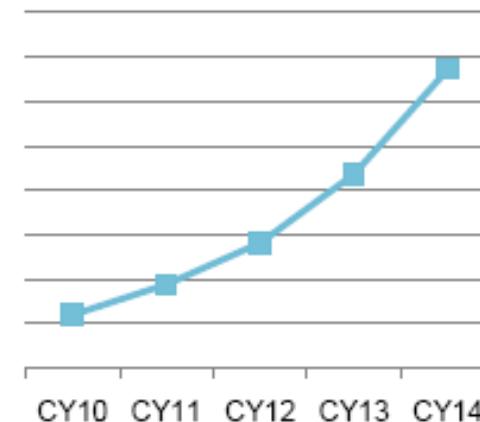
10G Networking Processing Challenges

- CPU load can exceed 50% of CPU utilization in typical 10G networking applications

- Convergence and Virtualization
  - Goal to increase average server utilization
  - Increase networking demands
  - Starving host CPU from value add tasks

- Network workload trends drives CPU utilization

- **As a result, there exists a large and growing need for intelligent programmable network solutions**

CPU cycles vs workload type

~10K cycles

~100 cycles

switching · routing · L4 classification · firewall · IPS · application firewall · VPN
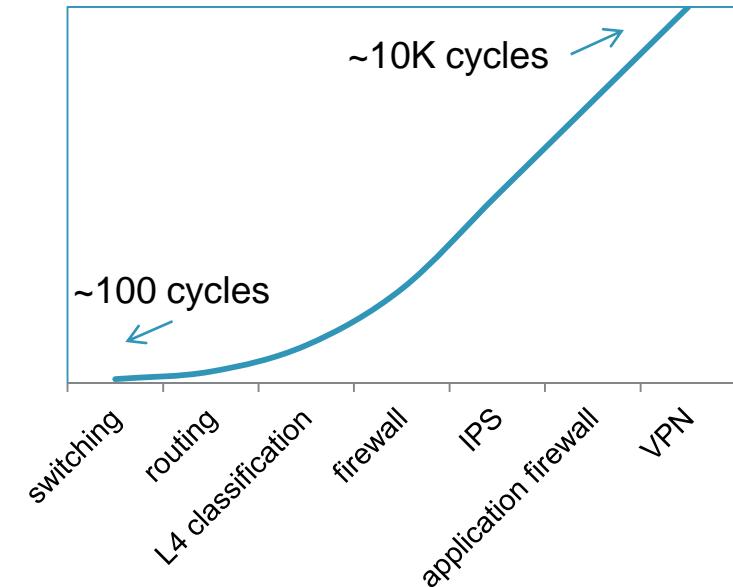
Work Scheduling and Hardware Acceleration

- Provide sharing of network interfaces and hardware accelerators by multiple cores

- Reduce software overheads associated with managing and moving "*work*"

- Congestion management and avoidance for higher data rates and distributed processing

- Hardware acceleration offload for compute intensive tasks – classifying, encryption, content processing

- The QorIQ Data Path Acceleration Architecture (DPAA) provides this infrastructure
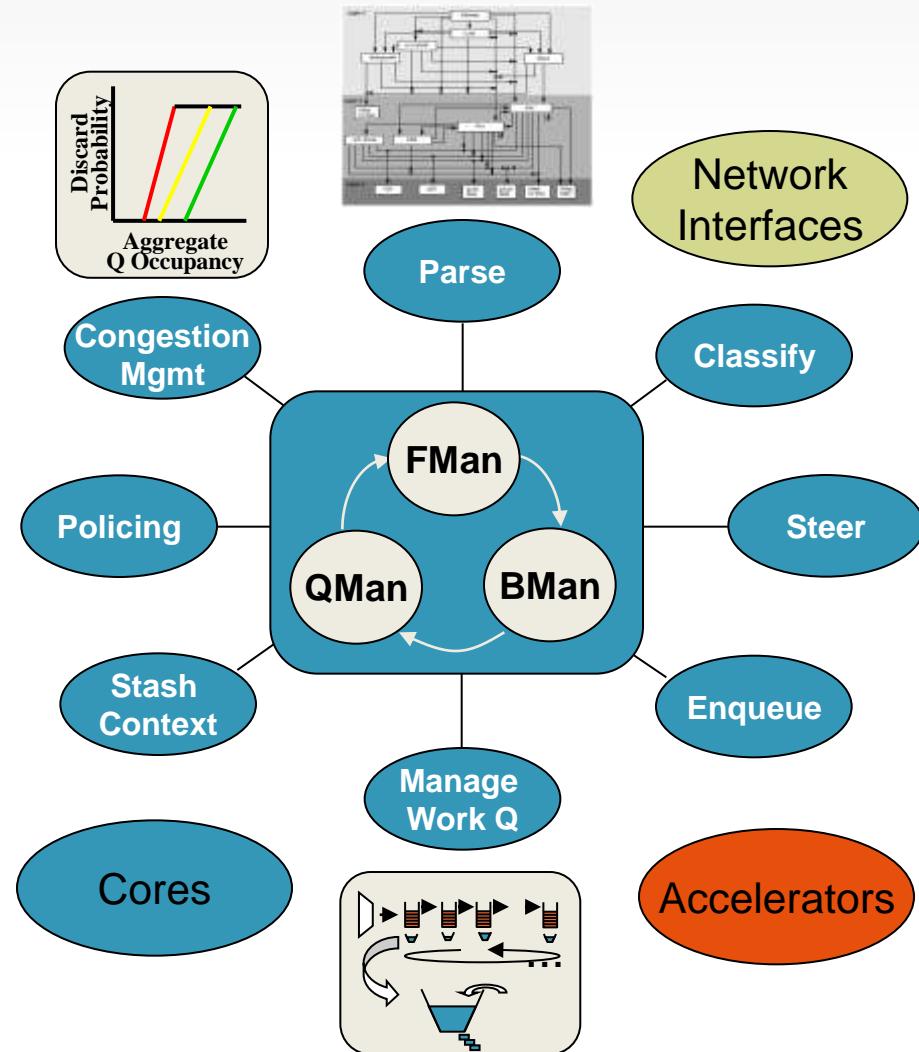
Management Processors for Switching Platforms

Management processors in Fixed Configuration Switches

Line Card processors in Modular Switches

Line Card processors in Data Center Top-of-Rack, End-of-Row & Core Switches

T1022

- **T1040/22** is a dual to Quad up to 1400MHz (2.4 DMIPS/MHz)
- Supports security & high availability through through secure boot and runtime monitoring

P1010

- **P1010** is entry level with 533 to 800Mhz with PCIE and SGMII.

P1011

- **P1011** is part of a scalable, pin-compatible processor family that goes from 400MHz single-core to 1.2GHz dual-core.

- **Typical Requirements:**
  - Single/dual core up to 1400MHz core
  - PCI-Express - One to four lanes x1
  - RGMII/SGMII – One to two GbE
  - DDR3L or DDR4
- **Additional Requirements:**
  - Security & High Availability
  - Virtualization to run 2 OS's
  - Low power

Guest OS #1	Guest OS #2
Linux / KVM / Qemu	
e500 CPU	
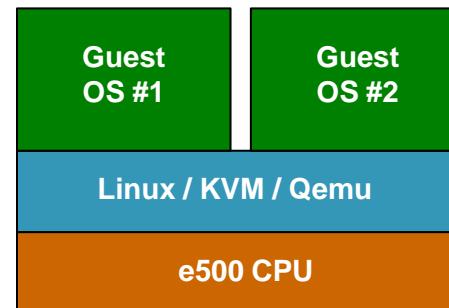
- QorIQ processors support virtualization: A single core can support two or more guest OS's over a Linux Kernel Based Virtual Machine (KVM).

Management Processors for High End Switching Platforms

Supervisor Card processors in Modular Switches

Supervisor Card processors in Data Center Top-of-Rack, End-of-Row & Core Switches

- **Typical Requirements:**
  - 2 to 4 cores at up to 1.5GHz
  - Mixed control and data plane
  - Multiple PCI-Express Gen 2 controllers
  - XAUI + multiple RGMII/SGMII
  - DDR3
- **Additional Requirements:**
  - Security & High Availability
  - Virtualization
  - Accelerators – RegEx, data path, crypto

Example QorIQ Processor Solutions
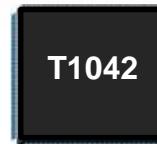
T1042

P2040

- **T1042 at 28nm or P2040** at 45nm is a quad-core up to 1.4GHz
- 1MB front-side cache
- 3 to 4 PCI-Express Gen 2 controllers
- 2 SATA, 5 Ethernet
- RegEx pattern matching acceleration
- Data path acceleration
- Security & High Availability
  - Crypto acceleration
  - Platform assurance via secure boot and runtime monitoring
  - Control plane policing
- Virtualization – supports HW hypervisor and IO MMU

P3041
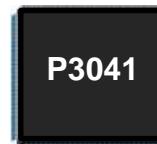
P5040

- **P3041** is a quad-core up to 1.5GHz with similar features as P2040 plus XAUI support and 128KB L2 per core.
- **P5020** is a dual-core up to 2GHz with 512KB L2 per core and 2MB L3.
- P3041 and P5020 are pin-compatible.

Key Values of the Freesale QorIQ Portfolio in Switching

- Industry broadest portfolio of solutions
  - P10xx → P30xx → P50xx
  - P204x → T1042 → T2080

- Industry highest performance on CPU core and balanced I/O for high performance control plane solutions

Features	Benefits
64-bit ISA Support	• The core utilizes 2x the amount of data per CPU cycle (64-bit vs 32-bit), increase performance for compute intensive applications • Increased addressable memory space allows a single process to have a larger address space, enables applications with large memory space.
7-stage Pipeline Out-of-Order Execution	• Core continues to do productive work in the event of a stalled instruction or a wrong branch prediction.
Floating Point Unit	• Classic double precision floating point →faster, accurate computation
Backside L2 Cache	• Provides a lower latency cache with higher bandwidth to the core Reduces the transactions on the shared interconnect and DDR memory
P5040 2.2Ghz T2080 1.8Ghz with 8 threads	• Higher frequency provides additional performance for 32-bit & 64-bit applications.

Processors for Application Delivery Networking

Application Delivery Controllers

- **Typical Requirements:**
  - 8 to 24 cores at 1.5GHz
  - Mixed control and data plane
  - Multiple PCI-Express Gen 2/3 controllers
  - XFI/XAUI + multiple RGMII/SGMII
  - DDR3/3L
- **Additional Requirements:**
  - Security & High Availability
  - Virtualization
  - Accelerators – RegEx, data path, crypto

Example QorIQ Processor Solutions
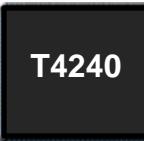
T4240
T4160

- e6500 dual threaded core upto 1.8Ghz
- Scale from 8 threads to 24 threads
- Large 2MB L2 cache per 4 core cluster
- XFI/XAUI/QSGMII/SGMII
- Upto 4 10GBE + 12GBE
- Upto 4 PCIE controller
- Update DPAA with DCB and more
- Updated virtu;ization support
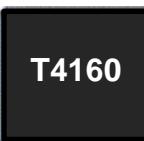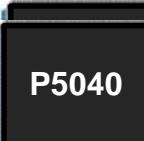
P5040
P3041
P5040

- P5040 at up to 2.2Ghz
- P4080/P3041 is an 4/8-core up to 1.5GHz (2.5 DMIPS/MHz)
- Upto 4 PCI-Express Gen 2 controllers
- Upto 8 Gigabit Ethernet, 2 XAUI
- RegEx pattern matching acceleration
- Data path acceleration
- Security & High Availability
  - Crypto acceleration
  - Platform assurance via secure boot and runtime monitoring
  - Control plane policing
- Virtualization – supports HW hypervisor and IO MMU

Network Services Controller
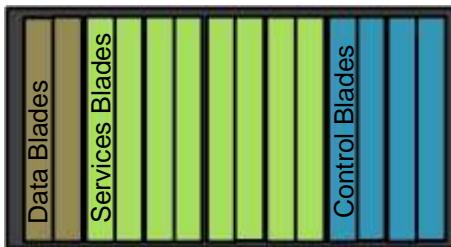
Applications

- Application Delivery Controllers (ADCs)
- Security Appliances (Firewall, IDS/IPS, AV)
- WAN Optimization Controller (WOC)
- Switch Services Controller
- Efficient compute – cost-effective application hosting and services delivery
  - Distributed Object Caching (e.g. memcached)
  - Distributed Compute (e.g. Apache Hadoop)

Heuristics, Correlation, Applications
X86, IBM Power7, QorIQ
2.5G→ 5G → 10G → 20G

Services Plane
Flow ID, Content (Pre) Processing
T4240
10G→ 20G → 40G → 80G

Data Plane
Simple & Fast Distribution/Load Balancing
Switches, NPUs, ASICs
40G→ 100G → 400G (?)

Linux	App	App	App
RTOS	Driver	Driver	Driver
Socket	USDPAA	USDPAA	... USDPAA

User Space

Hypervisor

QorIQ

DPAA

SEC
DCE
PME

Parse, Classify, Distribute

ETH · · · ETH · · · ETH

Use Case: Network Services Appliance
Branch Office 1U AND/UTM Appliance

| Heuristics, Correlation, Applications |
| Services Plane |
| Data Plane |

- 1U Network Service Appliance
- Combined Control, Service and Data Plane on T4240
- Quad 10G and 8GbE SoC
- User Space DPAA SDK

NEXCOM
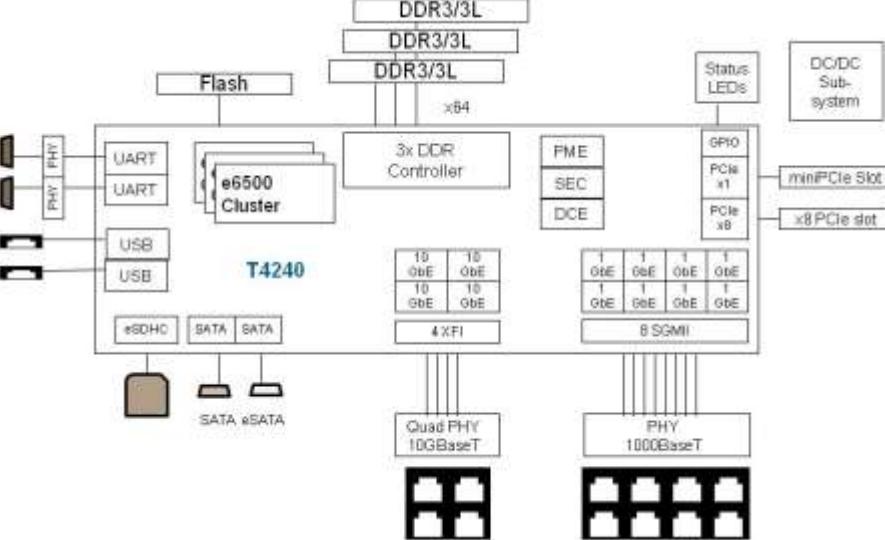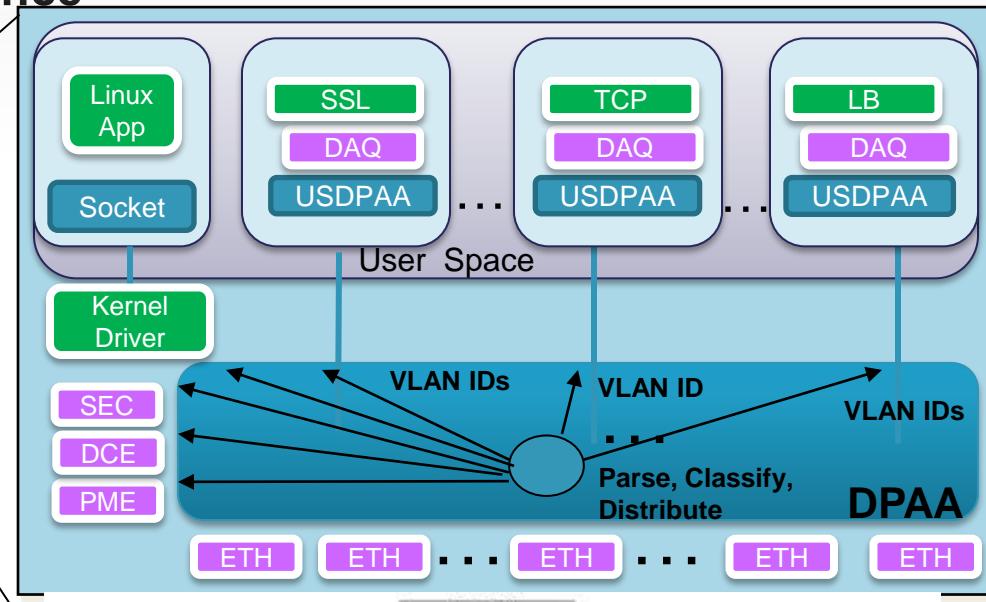
How Can QorIQ Be Relevant in Servers and x86 Hosted Appliances?

Simple NIC
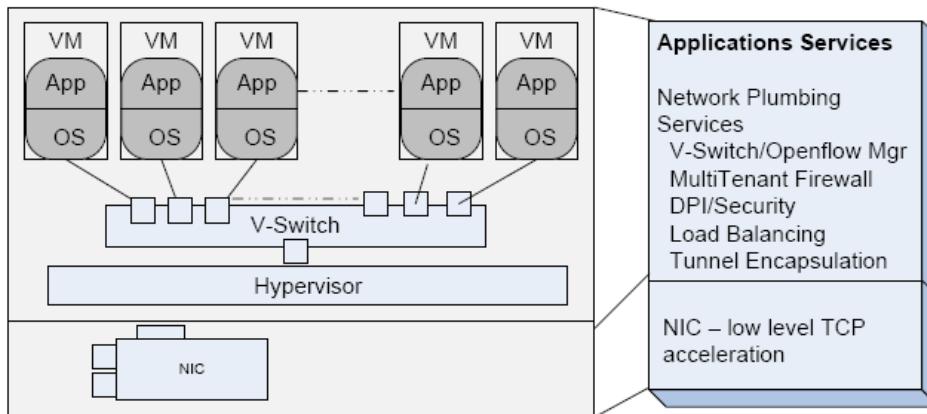
QorIQ Smart Virtualized NIC
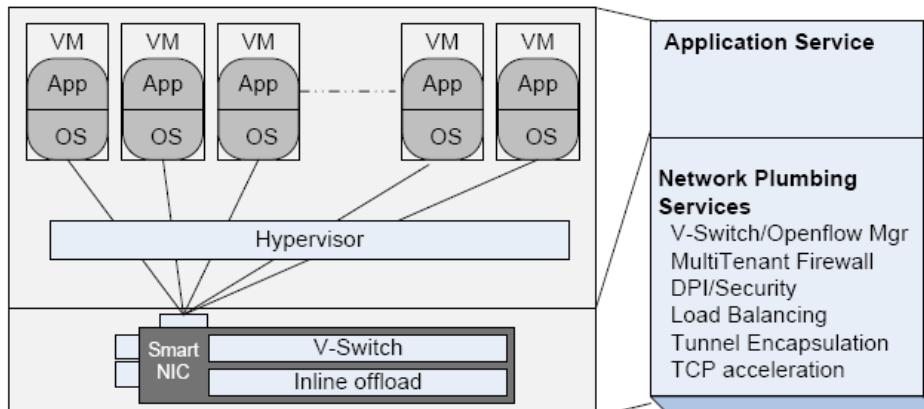
Reference: FTF-NET-0013: QorIQ Smart 10G Virtualized NIC

- Network Virtualization is driving new Data Center architecture
- Software Defined Networking and OpenFlow evolving technologies with many future enhancements
- Network Plumbing is a bottleneck for $ collection on the Server
- Multicore datapath adds flexibility and system level performance advantage
  - Target Server and purpose built server appliances

P4080PCIe – Base system SDK
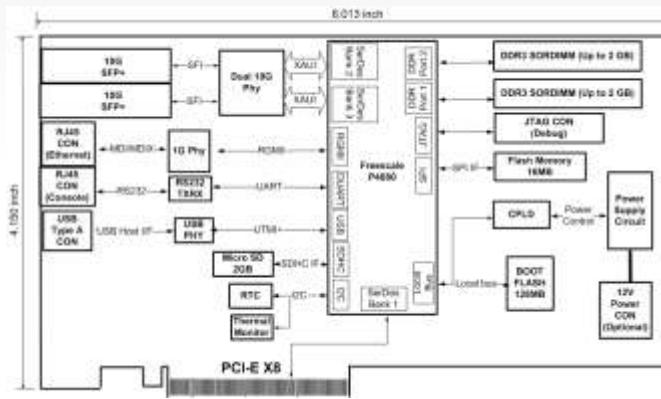
BSP

- Uboot
- Linux® 2.6.34 or later kernel and standard root FS
- LTIB SDK
- USDPAA Packet Driver enabling host access to P4080engines
- Host Interface Tools
- Cross Compile and native GNU tool chain
- CodeWarrior USB TAP (sold separately)

PCIe Tools

- Uboot
- Memory Access over PCIe
  - Read/Write to memory on adapter, exposed via a BAR
- Debug utilities
  - CCSR read/write and dump

Host Software

- PCIe Packet Driver
  - Example driver providing access to DPAA functionality
- Sample Linux® NIC Driver
  - Running over the PCIe packet driver
  - IP/TCP/UDP Tx and Rx checksum verification and generation
  - Link state management and reporting
  - Customary Statistics
  - Ethtool Support
  - Promiscuous mode option
  - Multicast filtering
  - Jumbo frame support, 9600KB max frame size
  - Support for two 10G ports
  - Support for multiple rings for multicore and virtualization environments

Example Use Case of P4080PCIe,
Edge Acceleration With P4080 or T2080

Open vSwitch Acceleration and offload for SDN Applications

- Intelligent Freescale QorIQ P4080 based PCIe adapter
  - Inline accelerated processing – octal cores
  - Hardware assist for Security & DPI
  - Dual 10G interfaces
- vSwitch datapath Offload
  - Free up resources on x86 host
- Application Specific Extensions & Programming
  - Flow based acceleration – Load Balancer Splice

- Network Virtualization
  - L2oL3 Tunneling – VxLAN, NVGRE …
- Future proof for emerging standards
  - OpenFlow versions – 1.0, 1.1, 1.2…
  - Revisions to Open vSwitch
- Scalability & Performance
  - 4M Flows   - Low latency
  - High-performance packet switching
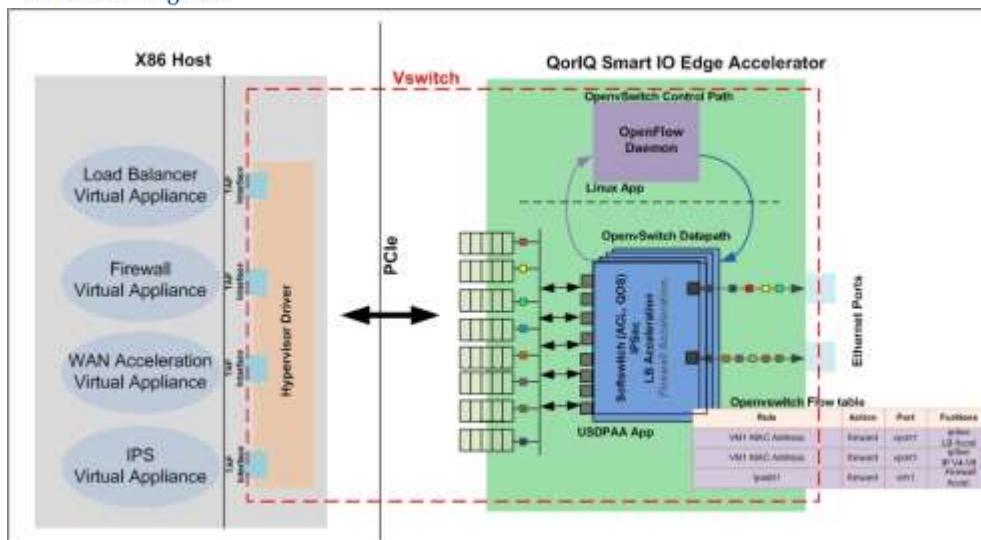
Target Applications
  Virtualized Servers
  Virtualized Appliances
  Edge Switches / L2oL3 Gateways
  Application Delivery Controllers
  WAN Acceleration
  Enterprise Firewalls / IDS / UTM
  Integrated Services Router
  Enterprise WLAN
  Storage Arrays
  Infrastructure as a Service (Cloud Services)
  Wireless Infrastructure

T series enhancement to Smart Virtualized NIC

SATA, USB, SD/MMC
• Lower system cost

SERDES
• Upto 10GHz
• XFI, XUAI, QSGMII, SGMII, PCIe, SRIO, Interlaken,

SEC 5.0
• Enhanced RSA Operation for SSL
   • 1024b RSA 25K operations
   • 2048b RSA 7.8K operations
• 40Gbps DES
• 40Gbps AES
• 20G CRC

PME
10G Regex Engine

DCE - Compression Deflate, GZIP, Zlib
• 10Gbps

Networking
• 48Gbps bandwidth
• 2x HiGig MAC
• IEEE802.3az (EEE)
• IEEE802.3bf (Time sync)
• Data Center Bridging (DCB)
   • Priority Flow Control
   • Enhanced Transmission Selection

PCIe Gen 3
• SRIOV EP

P1 UTM Appliance

Freescale P1011/P1020

Table Top

512/1GB 533MHz DDR3 on board

Memory

256MB for storage

NAND flash

NOR flash

2MB for Booting

RGMII

Marvell 88E6171R

USB

Console

Mini PCI-E

5 x Gbe Switch Ports

Freescale P1011/P1020 533MHz

Freescale P1020

1U

1 x SATA

1GB 667MHz DDR3 on board

Memory

Silicon Image

256MB for storage

NAND flash

NOR flash

2MB for Booting

Freescale P1020 800MHz

Console

RGMII

Marvell 88E6171R   **Marvell 88E6171R**

Transformer   Transformer

2x USB

Mini PCI-E

7 x Gbe Switch Ports

P1011 @ 533 MHz			
Application	**Throughput in Mbps**		
Packet Size	**Firewall**	**Firewall + IPS**	**Firewall + VPN**
64	93	19	28
390	486	93	131
Full Frame	1800	276	493

P1020 @ 800 MHz			
Application	**Throughput in Mbps**		
Packet Size	**Firewall**	**Firewall + IPS**	**Firewall + VPN**
64	150	34	51
390	782	167	237
Full Frame	2000	556	886

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P1010 Key Component BOM estimates

7 port Switch	$5.00
HW Security	Included
SATA	Included
SD/MMC	Included
USB PHY	Included
Power Circuit	$6.00
Passives & connectors	$7.00
Boot flash 64MB	$8.00
PCIe	Included
DDR3 512MB	$8.00
PCB	$8.00
P1010-533 10K units OEM	$15.44
Total eBOM	**$57.44**

Dash line indicates optional stuffing for upgrade models
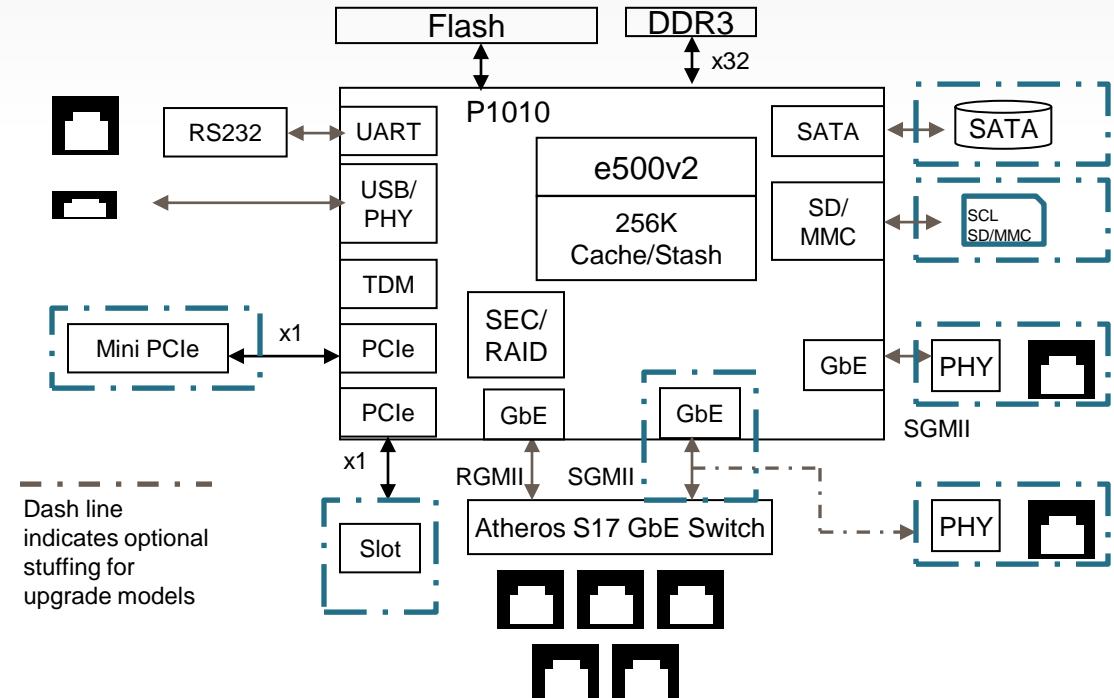
P1010 Performance Estimates	Firewall	IPsec VPN 3DES-SHA1	IPS SW DFA
P1010, 533 MHz, 1 core VortiQa software for Enterprise Equipment	1.8 Gbps**	493 Mbps**	219 Mbps**
P1010, 800 MHz, 1 core) VortiQa software for Enterprise Equipment	2.0+ Gbps**	650 Mbps**	290 Mbps**

** estimates based on P1011

P2040 Key Market Leadership
Uncompromised 5G UTM

	P2040- 1G
5x GbE PHY	$5.50
HW Security	
SATA	Included
Dual USB PHY	Included
Power Circuit	$7.00
Passives & connectors	$10.00
Boot flash 64MB	$8.00
PCIe	Included
DDR3 1GB DIMM	$23.00
PCB	$10.00
SoC 100Ku/yr OEM (P2040 1GHz)	$58.04
Total eBOM	$121.54

P2040 Performance Estimates	Firewall	IPsec VPN 3DES-SHA1	IPS SW DFA
P2040, 1.2GHz, Quad core VortiQa software for Enterprise Equipment	5 Gbps*	5 Gbps *	2 Gbps*

* estimates based on P4080 and P2020
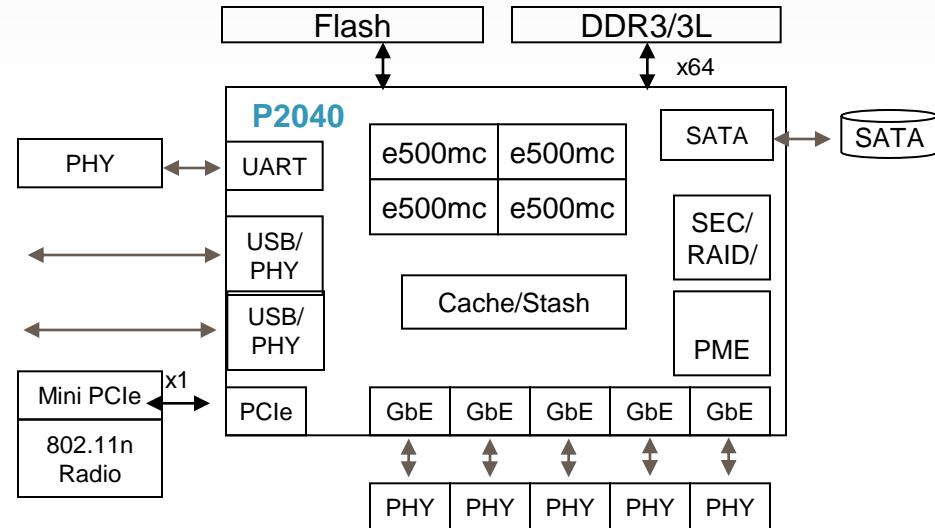
- System BOM and Performance
  - Massive Integration
  - Scalable to P4080
  - HW Acceleration
    - IPSEC/AES/RAID/Pattern matching

Low cost SMB 5G to 8G processing

P2040/41
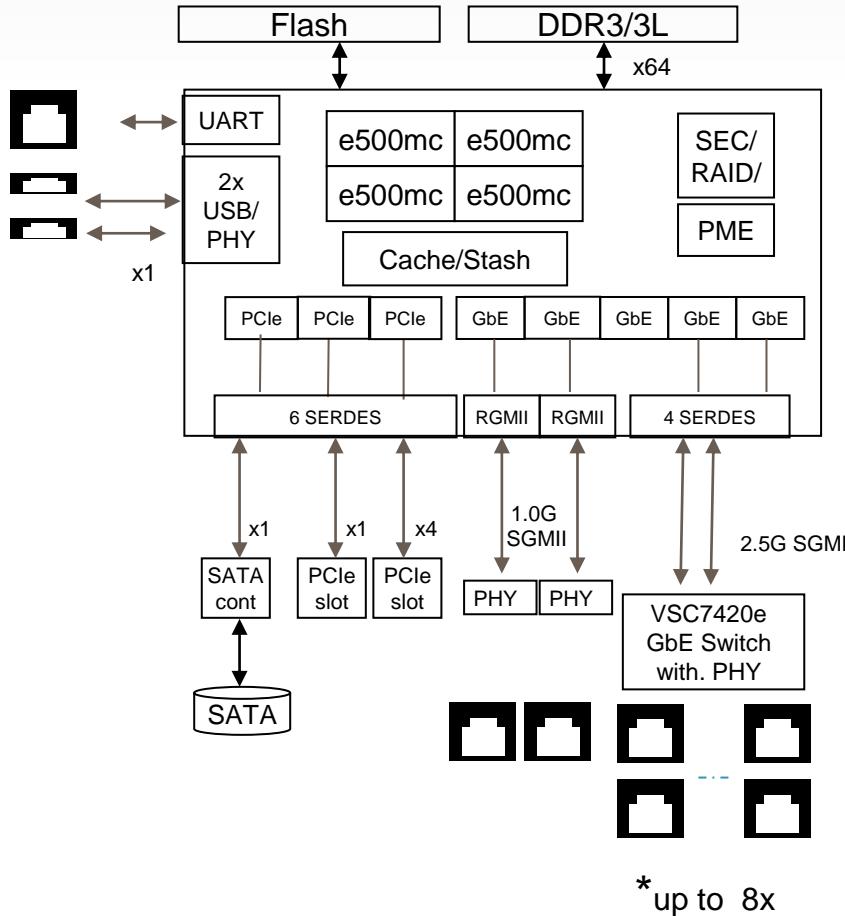
Upto 7G aggregate traffic
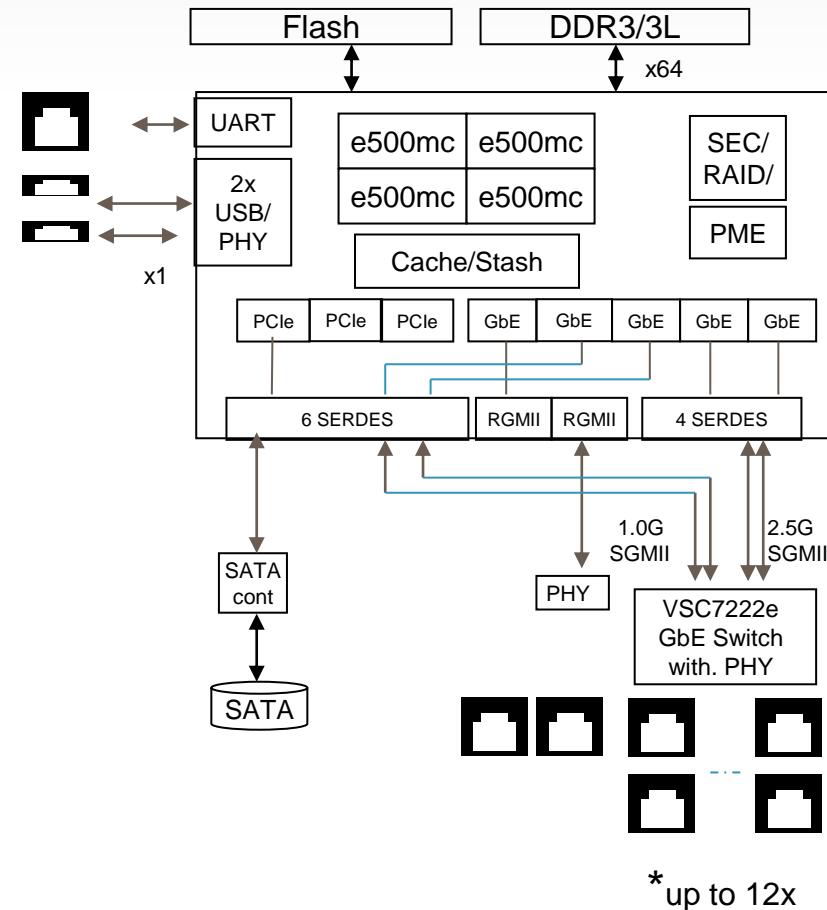
Upto 8G aggregate traffic

*up to 8x

*up to 12x

P2040 Block Diagram

4ports SFP

2ports 10 SFP+
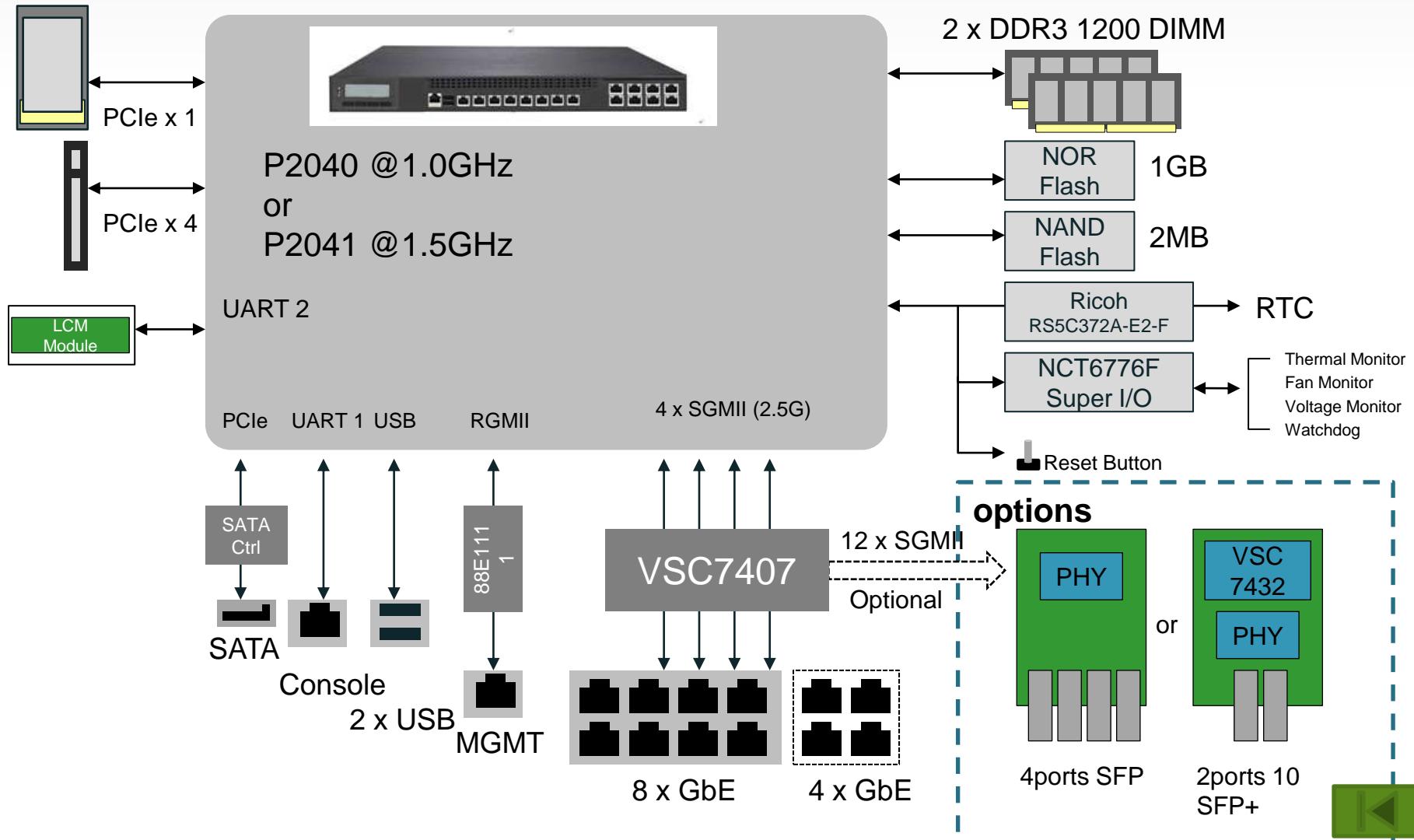
And finally, a brief look at the new QorIQ-LS1 product
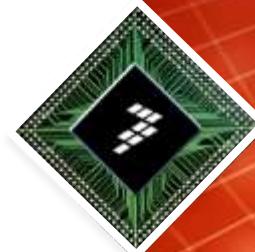
Comprehensive Portfolio Based on ARM Technology

ARM

Kinetis Microcontrollers
Design Potential. Realized

Industry's most scalable ultra-low-power, mixed-signal MCU solutions based on the ARM® Cortex™-M and Cortex™-M0+ architectures.

- **Consumer**
- **Industrial**

Vybrid Controller Solutions
Rich Apps in Real Time.

Real-time, highly integrated solutions with best-in-class 2D graphics to enable your system to control, interface, connect, secure and scale.

- **Consumer**
- **Industrial**
- **Automotive**

i.MX Application Processors
Your Interface to the World.

Industry's most versatile solutions for multimedia and display applications, with multicore scalability and market-leading power, performance & integration.

- **Consumer**
- **Industrial**
- **Automotive**

QorIQ Processors built on Layerscape Architecture
Accelerating the Network's IQ

Industry's first software-aware, core-agnostic networking system architecture for the smarter, more capable networks of tomorrow – end to end.

- **Consumer**
- **Industrial**
- **Networking**

Freescale has the industry's broadest range of solutions built on ARM® technology for automotive, industrial, consumer and networking applications.
Find your ideal solution at the price, performance and power level you desire,
and leverage the extensive software and tool bundles available to speed and ease your design process.

freescale™

QorIQ LS-1 Family

**First families based on Layerscape architecture
for the lowest-power tier of the QorIQ portfolio**

- Scalable portfolio of software- and pin-compatible products

- Purpose-built for fanless, small-form-factor networking
applications

  - High-performance ARM® Cortex™-A7 cores

  - Exceptional performance per watt enabling
    a new class of applications – starting at under 3W

- Advanced capabilities including virtualization support

- Combines Freescale networking expertise with ARM
ecosystem reach

freescale ™

QorIQ LS-1 Family
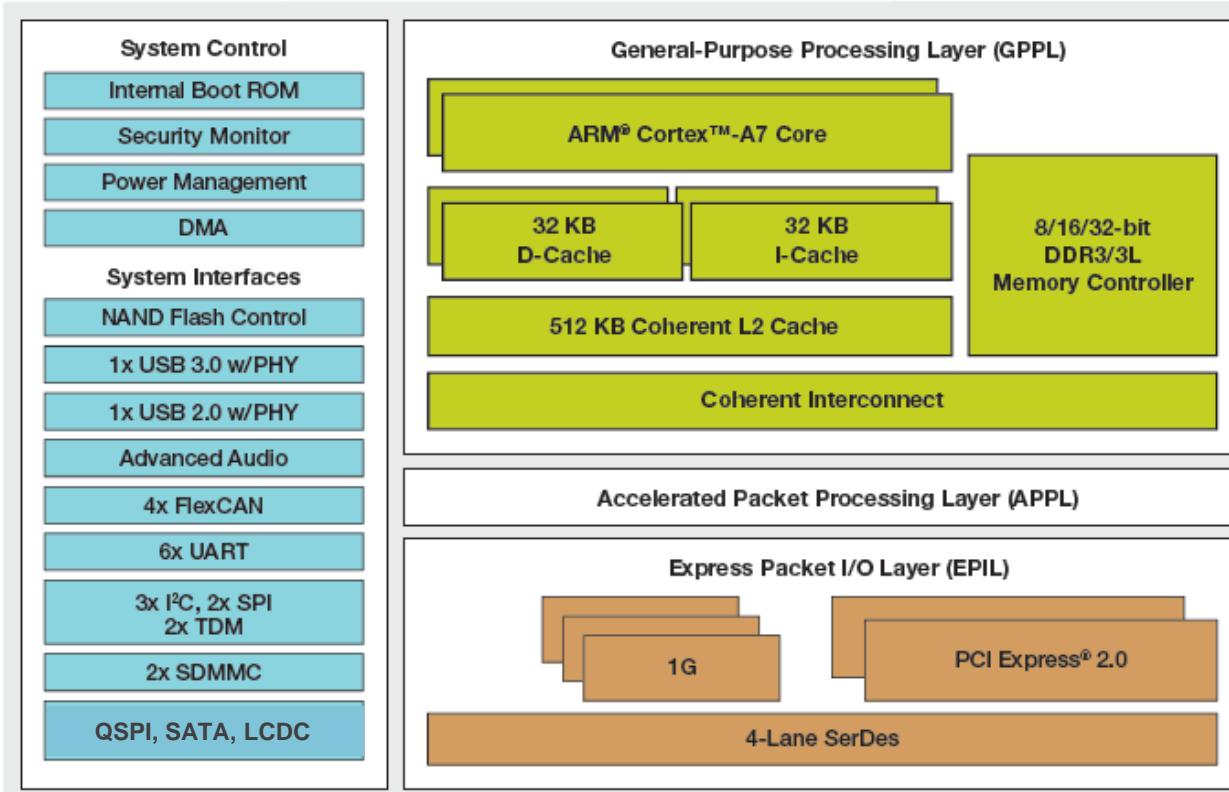
- Integrates dual **ARM Cortex-A7 cores** up to 1 GHz each

- **5,000 CoreMark®** of performance **under 3W**

- Enables **smallest form factor, fan-less designs**

- Ideal **migration path from MCU** based designs

- **Optimized performance to power** for networking applications, including:
  - Low end routers
  - Line cards
  - Industrial automation slave devices
  - Smart energy
  - Networked media hubs

Layerscape Architecture: High Level View

General Purpose Processing Layer (GPPL)

CPU(s) · · ·

Caches · · ·

Mem. Cont. · · ·

Application IO Processing Layer (AIOP)

Decomp Engine	Security Engine	Load Balance Engine	Pattern Match Engine	L2-L7 Switch Engine	Packet Buffer

Accelerated Packet Processor

Wire Rate I/O Processing Layer (WRIOP)

Ethernet Interlaken	100/40/10/1G	RapidIO	PCI-Express

SERDES

System Interfaces / Control / Tuning

Core Agnostic (ARM, Power Arch)
- Initial Product ARM V7.
- ARM V8 Product Roadmap.
- Continued Support for Power Arch.

Scalable Independent Layers
- Sized to Application Need.
- Real Time Monitoring / Debug.

Consistent Programming Interface
- Deterministic Performance.
- Complexity of HW Accelerator Hidden.
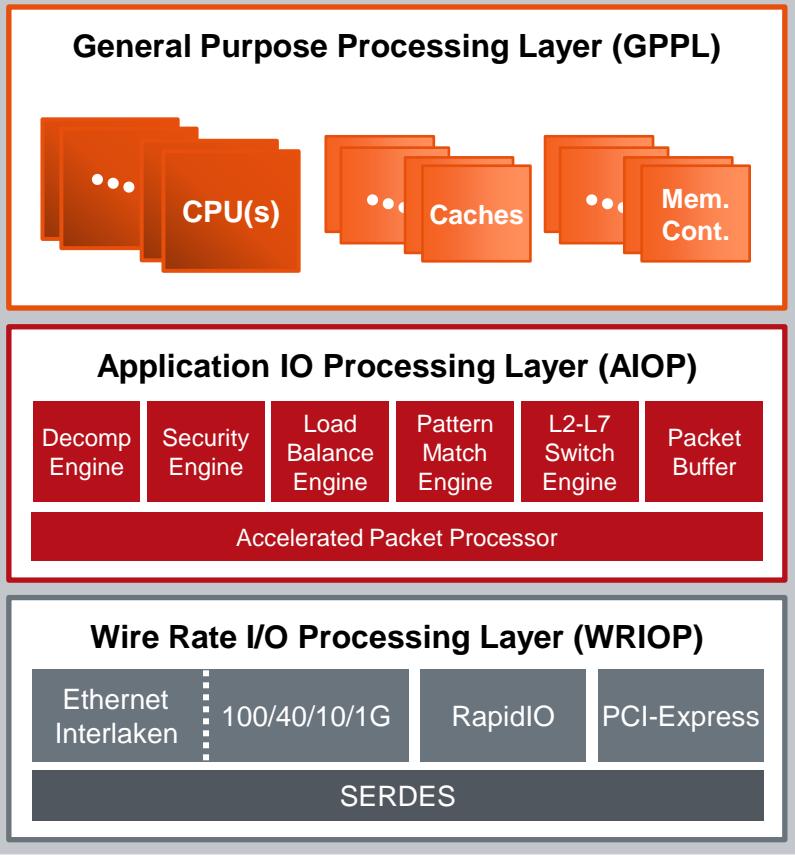
Programming Ease of General Purpose MPU, With Power Consumption Advantage of HW Acceleration, But Without Specific Programming Complexity
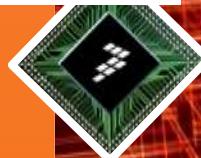
freescale ™

Summary

Freescale is leading innovation in next-generation network infrastructure

- Best-in-class execution on QorIQ → Industry leading reach and transparency.

- Exciting roadmap for the future → Leadership in multicore for the next 10 years.

- Infrastructure to accelerate your design → reference designs, collateral, **new exciting products!**