



Boot Up Your Personal Cloud with the QorIQ LS1024A Consumer **Network Attached Storage (cNAS) Solution**

AMF-SNT-T0979

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Agenda

- Introduction
- Overview of LS1024A Communication Processor
- LS1024A
- LS1024A Software Architecture
- Optimizations for consumer NAS
- NAS Benchmarks
- Roadmap
- Summary



Freescale Overview

- **A global leader in embedded processing**
- **50+** Year Legacy
- **Technology leadership – 6,000+** Patent Families
- **NYSE Listed** – Market Capitalization ~ \$7 billion
- **#1 or #2 Market Position** covers >80% of sales



Leadership in Networking Market

Market Leadership:

#1 Embedded Processors in Communications*

IDC

Freescale Share: 39%

Gartner

Freescale Share: 49%

Linley Group

Freescale Share: 40%

*Source: Gartner, Apr 2014, *Market Share: Semiconductor Applications, Worldwide, 2013, "Total Microprocessor Embedded in Wired + Wireless Communications"* (excludes DSP); IDC, July 2014, *Worldwide Communications Processor 2014—2018 Forecast and 2013 Vendor Shares*; The Linley Group, May 2014, *A Guide to Embedded Processors*.

Key Product Families:



QorIQ
Multicore
SoC Processors

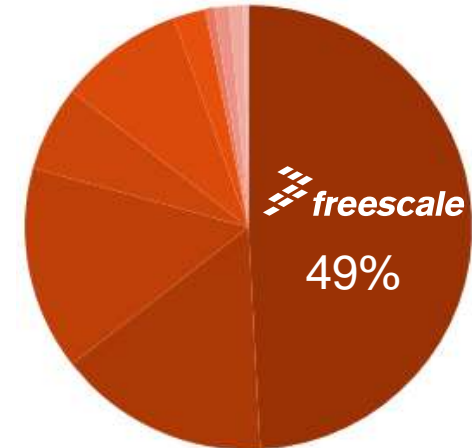


QorIQ Qonverge
Heterogeneous
SoC Processors



VortiQa
Software System Solutions
Software Services

2013 Market Share Embedded Processors in Wired & Wireless Communications



Source: Gartner, Apr 2014, *Market Share: Semiconductor Applications, Worldwide, 2013, "Total Microprocessor Embedded in Wired + Wireless Communications"* (excludes DSP)

Growth Areas:

- Multicore Processors
- Baseband Processors
- Cloud & Mobile Infrastructure Semiconductors
- Embedded Processors



NAS Market Trends

- Home / Small Office NAS
 - Becoming more multi-media centric
 - Apps Store model
 - Support for phones / tablets / PCs / smart TVs
 - Personal cloud
- Portable NAS / DAS
 - New paradigm to support data sharing among many portable devices
 - Power consumption / battery life is critical
- Ethernet Drives
 - Emerging opportunity in data center
 - Eliminate storage server bottleneck and reduce TCO

Freescale Storage Market Offering

The diagram is divided into three horizontal sections, each representing a different storage market offering. Each section features a processor icon with specific network and storage interface labels, descriptive text, and a representative storage device image.

- Cloud Storage (Top Section, Light Green Background):**
 - High performance Multi-core Communications Processors:** The processor icon has four red circles labeled "10G" at the top and three orange circles labeled "SATA", "PCIe", and "PCIe" at the bottom.
 - Low-power Processors For ethernet drives:** The processor icon has three red circles labeled "1G" at the top and three orange circles labeled "SATA", "PCIe", and "PCIe" at the bottom.
 - Image:** A stack of server hard drive bays.
- Enterprise Storage (Middle Section, Light Gray Background):**
 - High performance Multi-core Communications Processors:** The processor icon has four red circles labeled "10G" at the top and three orange circles labeled "SATA", "PCIe", and "PCIe" at the bottom.
 - Image:** A large enterprise storage server rack.
- Consumer Network Attached Storage (Bottom Section, Light Blue Background):**
 - Dual-core Low-power Communications Processors:** The processor icon has three red circles labeled "1G" at the top and three orange circles labeled "SATA", "PCIe", and "PCIe" at the bottom.
 - Image:** A small, vertical consumer network attached storage device.

NAS Success Stories

Synology DS414j 4-bay Consumer NAS















QNAP TS231 2-bay Consumer NAS












WD MyCloud Consumer NAS

Broad ODM support (partial list)

	LS102MA/LS1024A	VPN Concentrator/Router
	LS102MA/LS1024A	FTTH Ethernet HGW /Mobile broadband router
	LS102MA/LS1024A	FTTH P2P HGW/Service offload platform
	C100	FTTH P2P HGW, VDSL2 Premium HGW
	LS102MA	FTTH P2P HGW, 3G HGW
	LS102MA	Mobile LTE Broadband Router, Mobile LTE Office Router
	C100	FE Router
	LS102MA/LS1024A	FTTH Ethernet HGW, Service Offload Platform, LTE Router
	LS102MA	FTTH P2P HGW
	LS102MA	FTTH P2P, FTTH GEAPON HGU
	LS102MA/LS1024A	IMS-GW/Service offload Plat form
	LS102MA	FTTH P2P & Ethernet HGW

Software partners and ecosystem

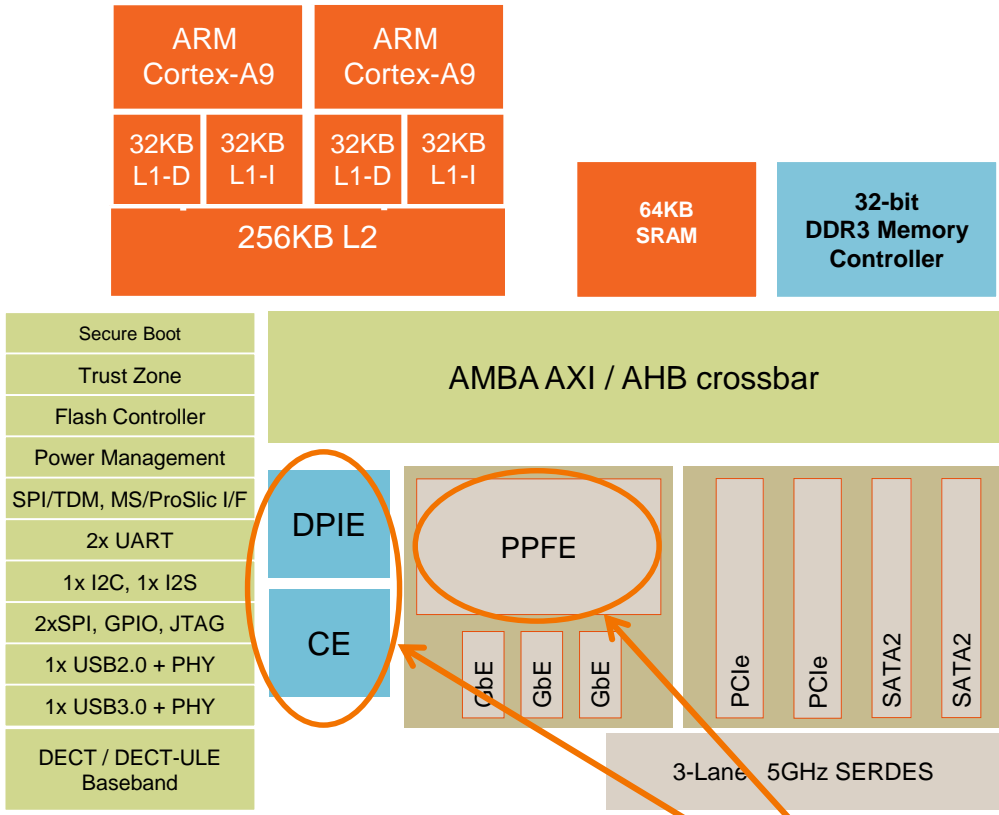
- The following vendors have developed software for LS102MA and LS1024A:

Vendor		Software
DigiOn		DLNA
JetHead		RVU server
Jungo		Residential gateway
Lionic		Deep Packet Inspection software
Prosyst		OSGI framework
RocketHome		Home Automation Application
Skelmir		Java Virtual Machine (JVM)
TeamF1		SMB Security Router
Apogee		Android Application Environment



LS1024A (aka Comcerto2000)

LS1024A Block Diagram



Datapath Acceleration

- **CE** - crypto acceleration
- **PPFE** - Programmable Packet Forwarding Engine
- **DPIPE** - Deep Packet Inspection Engine

Key Differentiators:

- Hardware Packet Acceleration & Inspection

General Purpose Processing

- 2 x ARM A9 CPUs, up to 1.2GHz
 - 256KB L2 cache
- Neon SIMD & FPU in all CPUs
- 16/32b DDR3 up to 1066MT/s

Accelerated Packet Processing

- 2Gbps PPPoE/NAT routing with 64B packets
- 2Gbps crypto acceleration
- Deep Packet Inspection Engine
 - Antivirus
 - Application-specific QoS
 - Advanced Diagnostics

DECT

- Integrated DECT and DECT-ULE baseband processor

High-speed Interfaces

- 2x PCIe 2.0, 1 lane each
- 2x SATA 2.0 with RAID 0/1/5
- 1x USB 3.0 with PHY
- 1x USB 2.0 (Host/Device) with PHY
- 3x GbE (3x RGMII or 2x RGMII and 1x SGMII)

LS1024A High Level Features

• Processing Unit

- Dual ARM Cortex A9 SMP/AMP up to 1.2GHz with NEON DSP and FPU
- 32KB/32KB L1 Cache & 256KB L2 Cache

• Data Interfaces

- 3x RGMII or 2x RGMII + 1x SGMII
- IEEE Std. 1588-2007 PTP V2 and 802.1AS
- 1x USB3.0 + 1x USB2.0 (Host/Device) with PHYs
- 2x PCIe Gen2 (5 GHz)
- 2x SATA2 with RAID 0/1/5 CTRL
- XOR engine

• Memory Interfaces

- Glue-less boot from NOR
- MLC support
- DDR3-1066 with ECC

• Control I/Os

- 1x I2C, 1x I2S, 2x SPI (up to 50 MHz with DMA)
- 2x UARTs (1x BT-capable + 1x Regular)
- Watchdog/Timers, RTC
- 16 dedicated GPIOs (+ 48 more mux'd),

• Boot Source Selction

- NOR, I2C, SPI, UART, SATA

■ Packet Accelerators

■ Programmable Packet Forwarding Engine (PPFE)

- 2Gbps of PPPoE/NAT routing with 64B packets
- HW QoS compliant to HGI2.0 on all data interfaces
- TCP Offload Engine

■ Hardware Security Engine

- Full IPsec offload delivers 2Gbps at 512-byte
- Full SSL offload delivers 200Mbps at 1500-byte

- Deep Packet Inspection Engine (DPI) up to 200Mbps

- A/V across several packets
- Application Specific QoS

■ Telephony Functions

- DECT base station CAT-iq 2.0 compliant
 - SW upgradeable to 2.1 and 3.0
 - Supports DECT-ULE
- TDM supports wideband Voice

■ Hardware/Silicon Security

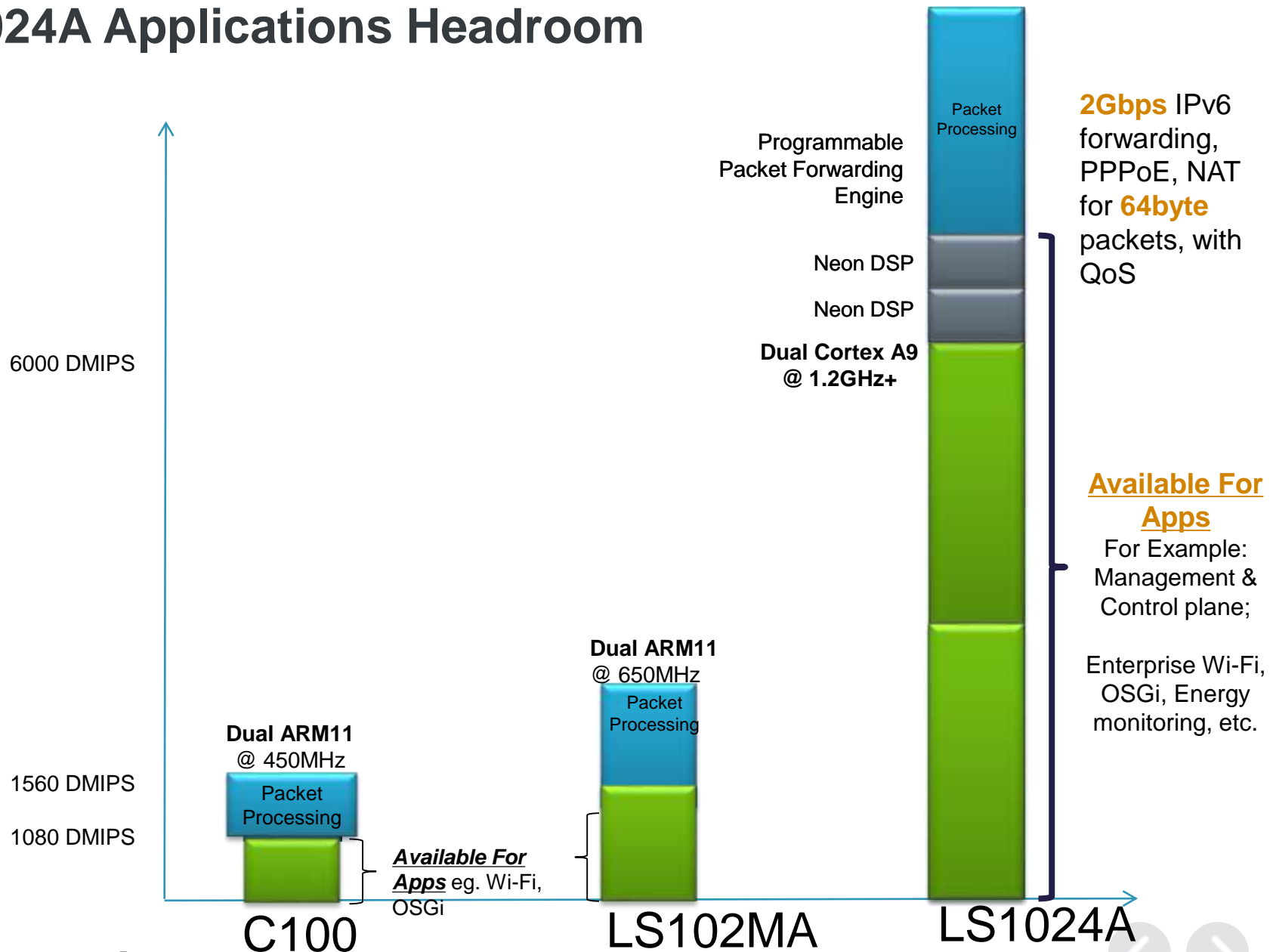
- Secure Boot, JTAG Blocking, 8Kb OTP Memory

■ Extensive Power Management Features

- Power islands
- Dynamic Voltage and Frequency Scaling (DVFS)
- Power Management Unit (PMU)



LS1024A Applications Headroom



LS1024A deliverables



Silicon

Engineering samples
Production samples
Volume

Available



Hardware (EVM)

Functionality Demos (with PAE)
Customer software dev vehicle

Available



Documentation

Schematics, Layout Guide, BOM
Data Sheet, Application notes and
Documentation

Available
Available



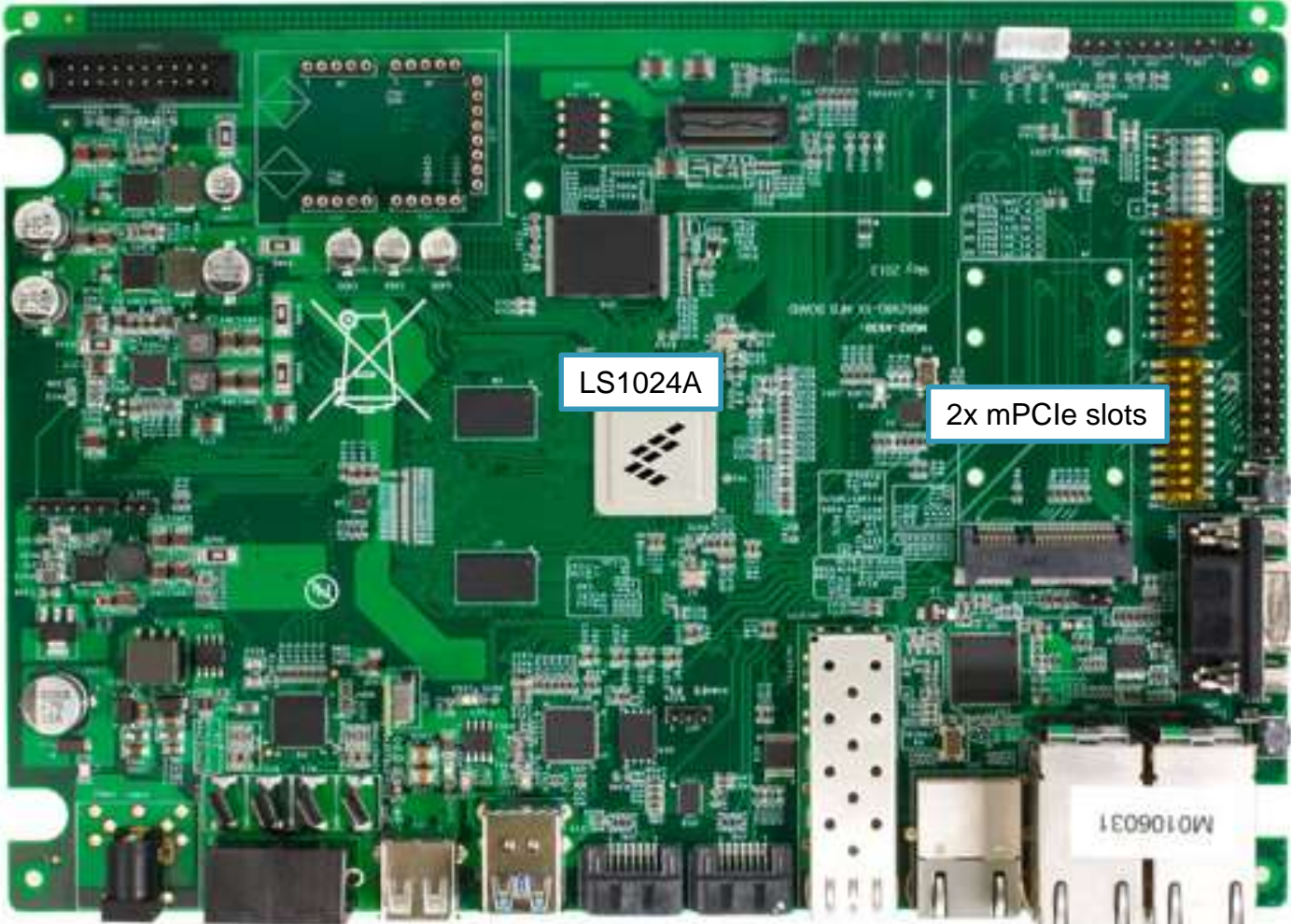
Software

OpenWRT Linux-based ASKs for
Storage and Routing applications

Available



LS1024A-RDB



LS1024A

2x mPCIe slots

2x FXS

USB3.0+USB2.0

2x eSATA

SFP+ GE WAN

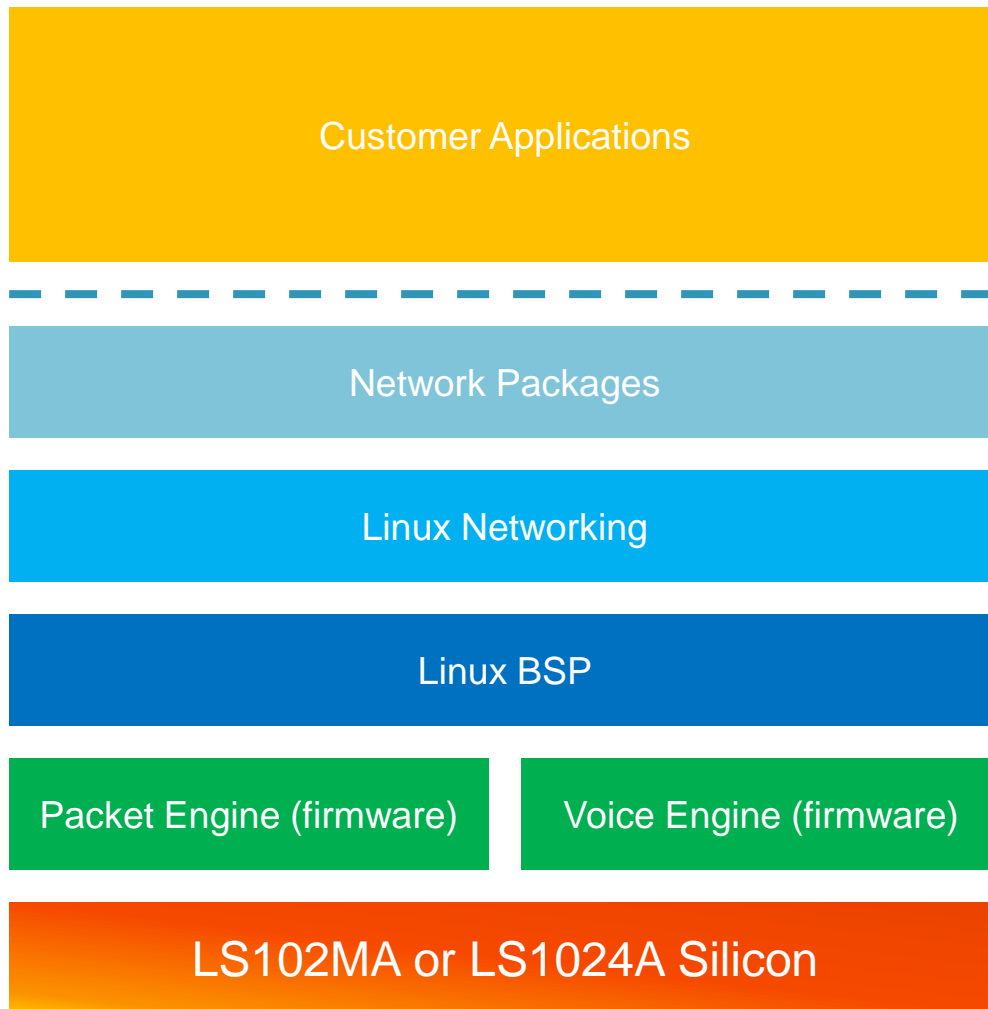
4x GE LAN





LS1024A Software Platform

High-level System Architecture & Development Model

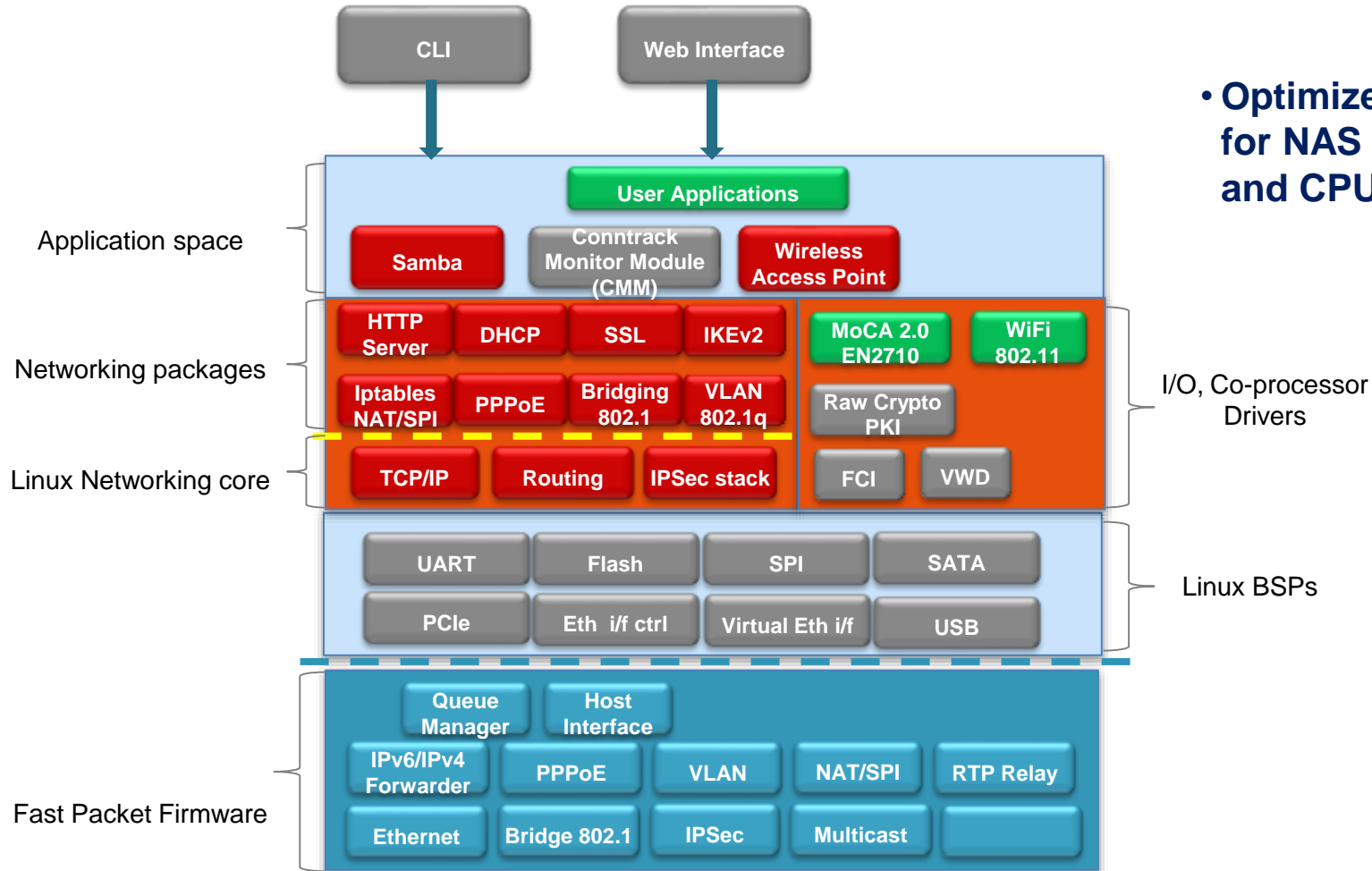


- Customers interface with system at API level
- Changes/New features requests submitted to Freescale for support

- ASK includes firmware & optimized network and Linux packages
- Hardware details abstracted by ASK for rapid product development

LS1024A Application Solution Kit – NAS Architecture

■ Freescale software binaries
 ■ Freescale software source code
 ■ Open source software
 ■ 3rd party Software



• **Optimized at all levels for NAS Performance and CPU offload**



Summary of Software Platform offer

Item	Resale Price	Description	Tech support by FAE/DFAE/TIC	Support & Maintenance by Factory Software Team
LS1024A-RDB	\$2000	Evaluation Board – ships with pre-loaded binary image ADK	Yes	Not included
LS102MA-RDB	\$2000	Evaluation Board – ships with pre-loaded binary image of ADK	Yes	Not included
Software Development Kit (SDK)	No-cost	General Enablement Platform – source code delivery without fastpath, security acceleration & VoIP	Yes	Not included
LS102MA-SW-ASK*	\$5000	LS102MA source code delivery of ASK.	Yes	Not Included**
LS1024A-SW-ASK*	\$5000	LS1024A source code delivery of ASK.	Yes	Not Included**

*VoIP DSP code and Packet Engine code are always supplied as binary libraries

**Annual Software Support & Maintenance Service Plans are available for purchase – see next slide

Software Support Service Plans

Part Number	Resale Price	Description
LS1024A-SWSP-PRM	\$50,000	LS1024A Software Support Plan – Premium Level
LS1024A-SWSP-PLS	\$25,000	LS1024A Software Support Plan – Plus Level
LS1024A-SWSP-BAS	\$15,000	LS1024A Software Support Plan – Basic Level
LS102MA-SWSP-PRM	\$50,000	LS102MA Software Support Plan – Premium Level
LS102MA-SWSP-PLS	\$25,000	LS102MA Software Support Plan – Plus Level
LS102MA-SWSP-BAS	\$15,000	LS102MA Software Support Plan – Basic Level

Software Commercial Support Program

QorIQ LS1024A and LS102MA Support Plan Options

Support Level	Premium	Plus	Basic
Part numbers—LS1024A	LS1024A-SWSP-PRM	LS1024A-SWSP-PLS	LS1024A-SWSP-BAS
Part Numbers—LS102MA	LS102MA-SWSP-PRM	LS102MA-SWSP-PLS	LS102MA-SWSP-BAS
New ASK software releases*	•	•	•
Assigned a Voucher ID for software support issues	•	•	•
Access to test codes to facilitate early feature integration	•	•	
Ability to request custom features	•		
Software support hours included	240	100	50
Additional software support hourly rate	\$175	\$200	\$225
Issue tracking database	Access limited to 10 users	Access limited to 3 users	Access limited to 1 user
Annual Fee	\$50,000	\$25,000	\$15,000

* New ASK Software Releases—Regular updates to the QorIQ LS1024A and LS102MA software are made available via Freescale production and patch releases.

LS1024A & LS102MA Software Options Comparison

	Application Development Kit (ADK)	Software Development Kit (SDK)	Application Solution Kit (ASK)
Price	Free with Reference Design Board (RDB)	Free of charge	\$5000 Resale
Use-cases	<ul style="list-style-type: none"> - Evaluation - Application Development 	<ul style="list-style-type: none"> - System Development & Production (low-speed networking) 	<ul style="list-style-type: none"> - System Development & Production (high-speed networking)
OpenWRT tool chain	No	Yes	Yes
Boot-loaders	Binary only	Source code	Source code
VoIP Firmware	Yes	No	Yes
Packet Engine Firmware	<ul style="list-style-type: none"> - Fast packet forwarding - Hardware security acceleration 	<ul style="list-style-type: none"> - Standard Networking - Security not accelerated 	<ul style="list-style-type: none"> - Fast packet forwarding - Hardware security acceleration
Networking performance	<ul style="list-style-type: none"> - Up to 2Gbps Ipfwd - Up to 2Gbps IPsec 	<ul style="list-style-type: none"> - Limited by CPU Software performance 	<ul style="list-style-type: none"> - Up to 2Gbps Ipfwd - Up to 2Gbps IPsec
Power Mgmt Unit	Supported	Not supported	Supported
Commercial Support	- Available	Available	Available

LS102MA/LS1024A ASKs: Broadband Home Router (BHR)

- OpenWRT ASK, targeted at BHR/HGW application
 - Complete OpenWRT build environment and BSP
 - Typical WiFi router application
 - Includes all needed features, e.g. DHCP, DNSMASQ, iptables, WebIf
 - Binaries for QCA, BRCM, RTL WiFi and L2SW
 - Binaries for Microsemi, Prosilic SLICs
 - Binaries for FPP/PFE and MSPvoip, sources for cmm
 - Security engine APIs integrated into ASK
 - openssl, openswan
 - Asterisk Channel Module as demo-level example
 - Uses MSPvoip & VAPI library
 - WebIf or command line control
 - Usually customized by customer, e.g. own branding
 - Board configs for LS102MA and LS1024A EVMs
 - Docs show how to modify config for customer board
 - u-boot, barebox (LS1024A)
 - kernel 2.6.33.5 (LS102MA), 3.2.26/3.2.54 (LS1024A)
 - jffs2, ubifs filesystem. nfs available with LS102MA



Network Attached Storage (NAS) ASK: LS1024A only

- OpenWRT (Attitude Adjustment) ASK, targeted at NAS application
 - Complete OpenWRT build environment and BSP
 - Typical NAS application
 - Includes all needed features, e.g. DHCP, DNSMASQ, iptables, WebIf, samba
 - Binaries for QCA, BRCM, RTL WiFi and L2SW
 - Binaries for PFE (NAS-specific) and MSPvoip, sources for cmm
 - Security engine APIs integrated into ASK
 - openswan, openssl
 - WebIf or command line control
 - Usually customized by customer, e.g. own branding
 - Board configs for LS1024A EVMs
 - barebox
 - kernel 3.2.32/3.2.54
 - Kernel options tuned for NAS
 - jffs2, ubifs filesystem



LS102MA and LS1024A System Software

System Features			
kernel (glibc/uclibc)	File system support	TCP	Netfilter
Atheros WiFi Drivers	NOR boot	UDP	Conntrack
Ralink WiFi Drivers	Asterisk – telephony	ICMP	SSH
Zarlink SLIC/SLAC drivers	System Management / Configuration	ARP	NTP client
SiLabs SLIC/SLAC Drivers	HW QoS configuration	Static Routing	Tcpdump
CLI interface	Samba	IGMP	Smbd
Customizable GUI	FTP	Private Network Address Allocation	MACVLAN
USB Stack	Firewall	DHCP Server	IGMP proxy
PCIe Stack	Port Forwarding	DHCP Client	Cyclesoak
I2C Driver	Traffic Shaping	DNS Proxy / Server	Timer control
SPI Driver	IPv4 / IPv6 - bridging / Routing	Private Network	HW Watchdog support
GE Ethernet MAC Drivers	HTTP	IPv6 Neighbor discover	PPPoE
Virtual Ethernet Drivers for MSP communication	Telnet	Ipv6 Auto-configuration	OpenSSL
IPSec Engine control	NFS	Multicast	IKE
UART access	UPnP / DLNA	MLDv2 / MLDv2 snooping	Connmark
GPIO Control	NAT	IPv4/IPv6 dual stack	Iptables
Interrupt service routine	VLAN	OCF for IPSec	tunneling

Fast Forward Features	
IPv4	IPv6 Neighbor Discovery
IPv6	IPv6 Auto-configuration
PPPoE Relay	MLDv2
IPSec	4rD
SSL	4over6
Multicast	VLAN
Fragmentation and reassembly	L2 Bridging
Multicast	Advanced QoS
UDP	Traffic Shaping
TCP	WiFi Routing / Bridging Offload
ICMP	PPPoE
ARP	RTP Relay
Static Routing	MACVLAN
IGMP	DSCP Marking
Private Network Address Allocation	Rate Limiting
DHCP Server /Client	Programmable timeout
DNS Proxy / Server	PPPoE auto (dial on demand)
NAT	Statistics

Comparison with Freescale Digital Networking standard SDK

- Standard Freescale SDK is a generic enablement package for a wide application space
- LS102MA and LS1024A ASKs are full-featured reference solutions with Optimized firmware and pre-integrated middleware
 - Closer to the Software Segment Solutions' SDK supplied with the P1020EWLAN:

Solutions References 

Wireless Router/Gateway



- **Linux and OpenWRT**
- **Wireless Router Enablement Software includes**
 - 802.11 a/b/g/n, IPv4, DHCP, DNS, VLAN, NAT/PAT, Static routing, VRRP, PPPoE, IGMP, UPnP, SNMP
- **Network Video Record(NVR)**
 - IP camera video
 - Virtual camera display, Video stream record, Video file replay
- **Network Access Storage(NAS)**
 - USB-Disk/CF support
 - Raid disk management, Volume management, Snapshot management
 - Samba/NFS/FTP/file share, Backup
- **Network access control Wireless Security**
 - Pre-Shared Key (PSK)
 - Wi-Fi Protected Access 2 (WPA2)
 - 802.11i AES-CCMP
 - Wired Equivalent Privacy (WEP), 128/256-bit
 - 802.11i EAP authentication with RADIUS
- **Network Security**
 - Access control
 - Stateful packet inspection firewall
 - Intrusion detection
 - Content filtering
- **Virtual Private Network (VPN)**
 - IPSec, PPTP, L2TP

 Confidential and Proprietary | 25  



LS1024A Optimizations for NAS

NAS Data path Optimizations

- **Minimize copy**

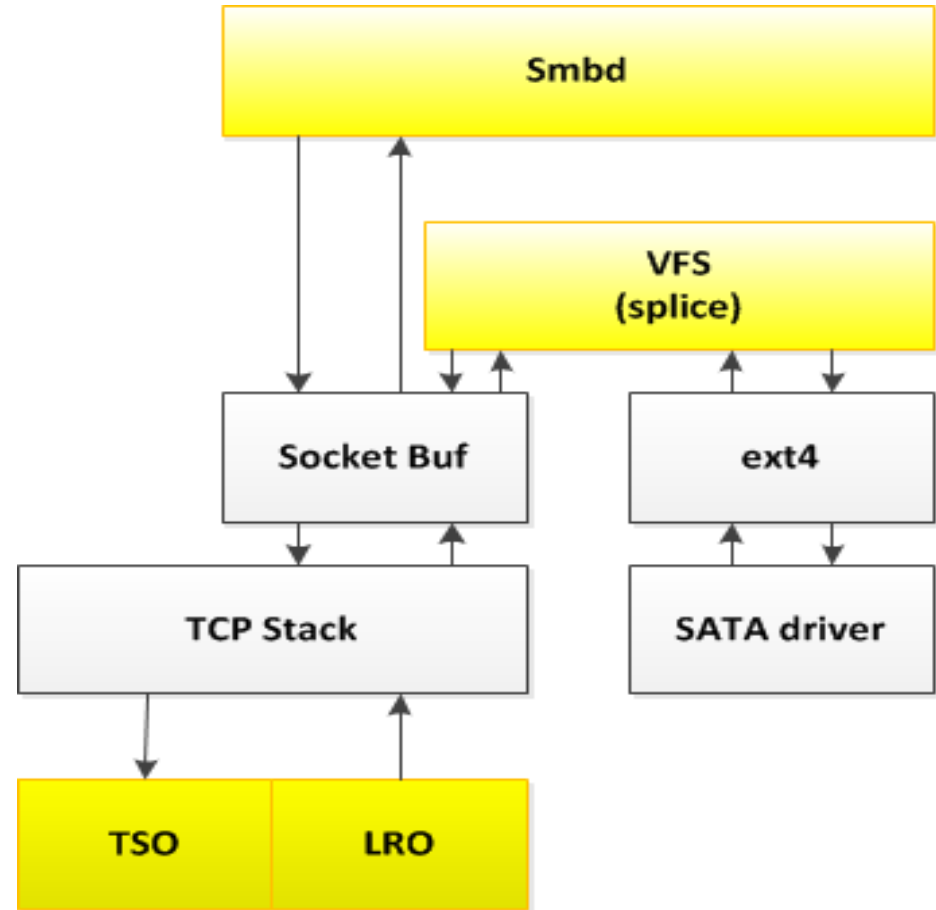
- DMA engines are used whenever data need to be move

- **Minimize overhead**

- Reduce number of packet crossing the TCP stack
- Reduce copy between user space and kernel space
- Reduce cache maintenance operation

- **TSO / LRO**

- Offload to hardware packet engine

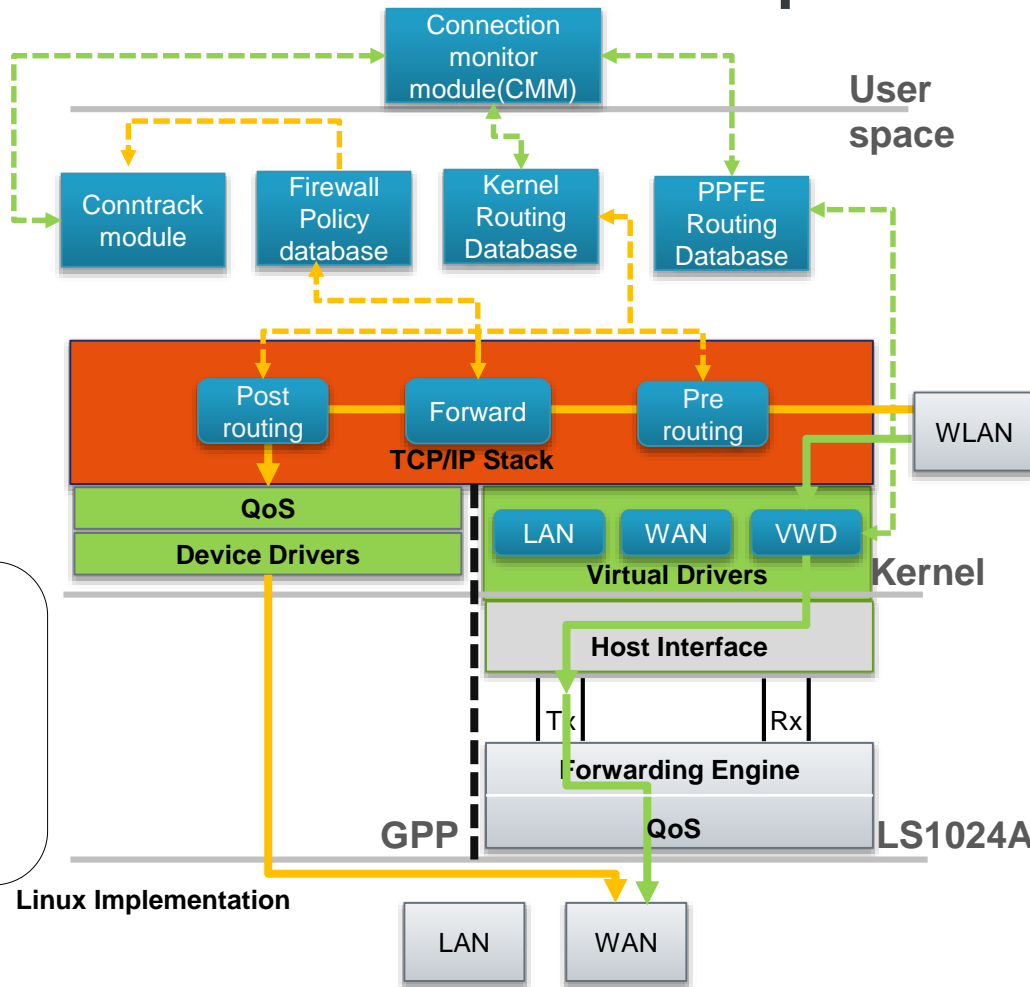


Conntrack Monitor Module (cmm)

- User-space application which is hooked into the Linux networking stack
 - A kernel module, FCI handles communication with FPP
- cmm is aware of networking events
 - e.g. a packet on a new connection is allowed by iptables (Linux firewall)
- Automatically updates connections for fast-forwarding to FPP
 - e.g. the new connection is fast-forwarded by FPP
- Once a connection is fast-forwarded, some packets must still come to Linux
 - e.g. TCP protocol messages. This ensures Linux maintains the correct connection state.
 - e.g. SIP protocol messages. This is to allow VoIP NAT traversal to work.
 - There is a list of fast forward 'deny rules' that control which protocol packets are not fast-forwarded.
- Often cmm is transparent to users
 - Some cmm features need direct configuration, e.g. Multicast, RTP Relay
 - cmmlib is used by customer applications
 - cmm client interface useful for debug



LS1024A Wi-Fi Offload vs Generic Implementation



In generic implementation the entire packet processing is done by the TCP/IP stack which results in reduced performance and increased CPU load.

LS1024A offload architecture will bypass the Linux stack and the packet is intercepted by the Virtual Wireless Driver (VWD) and processed by the hardware forwarding engine which results in class leading performance and reduced CPU load.

- Packet flow with LS1024A hardware offload architecture
- - - Control path specific to LS1024A hardware offload architecture
- packet flow in a generic implementation with out any acceleration
- - - Control path in generic Linux implementation

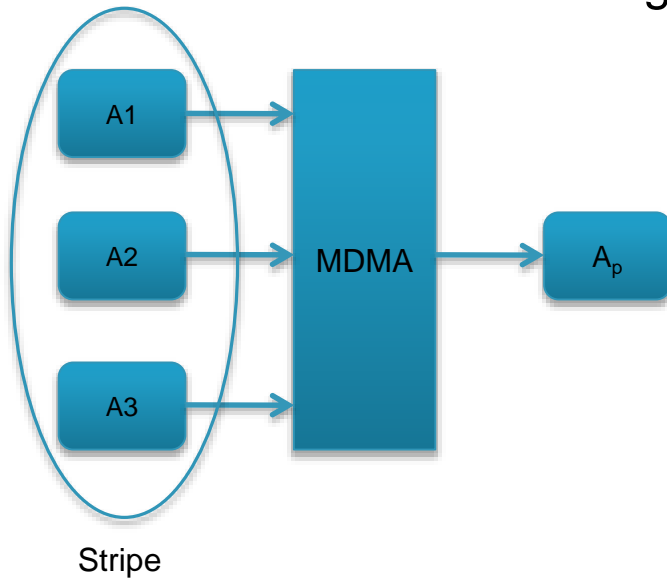


LS1024A SAMBA Optimizations

- Improve read/write efficiency
 - Use optimized sendfile and splicewrite calls
 - Routines are optimized for memory usage and accelerated by HW DMA engine
- Reduce memcopies caused by user space <-> kernel space transitions
- Support 64KB pages
- Code optimization of key routines for performance
- Simplify memory allocation to reduce overhead
- Optimization of Linux cache management to minimize overhead for flushing caches, etc.

Multi-purpose DMA Engine

- MDMA is used to accelerate Memcopy with simple APIs exported to Linux kernel
- Splice writes modified to call DMA memcopy
- Support for Scatter / Gather
- RAID5
 - Linux RAID5 driver optimized for zero copy
 - Uses HW XOR via DMA engine



- RAID5 is supported with hardware accelerated Parity calculation
 - DMA engine running at 266MHz
 - Accepts blocks belonging to a stripe as input
 - Produces a block of Parity data as output
 - Software can continuously feed the DMA engine with stripes

LS1024A NAS Optimizations Summary

- Datapath
 - Minimize overhead
 - Minimize data copy operations
 - Use DMA engine where copy is necessary
 - TSO & LRO implemented on hardware packet engine
 - SATA read burst size tuned for best performance
 - Virtual WiFi driver intercepts packets and passes them directly to/from packet engine
- SAMBA optimizations
 - Improve read/write efficiency
 - Reduce memcopies
 - Support 64KB pages
 - Code optimization of key routines for performance
- Multi-purpose DMA Engine
 - Used instead of CPU for memcopy
 - Supports scatter-gather
 - Hardware XOR for RAID5 support
- Linux Cache management optimization to minimize overhead



LS1024A Performance

LS1024A Application Performance

WAN -LAN: IP Forward/NAT routing

Frame size (B)	Bi-dir throughput (IPv4) - Mbps	CPU utilization	Bi-dir throughput (IPv6) - Mbps	CPU utilization
64	2000	<2%	2000	<2%
128	2000	<2%	2000	<2%
256	2000	<2%	2000	<2%
512	2000	<2%	2000	<2%
1024	2000	<2%	2000	<2%
1280	2000	<2%	2000	<2%
1518	2000	<2%	2000	<2%

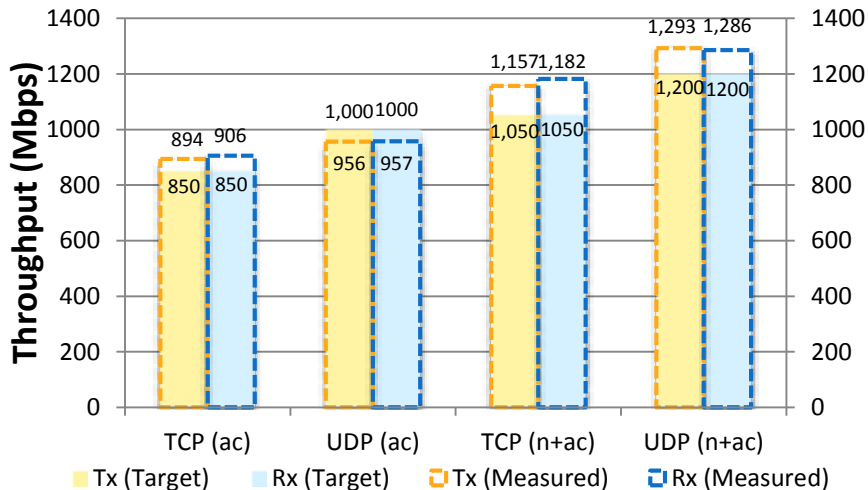
Security Applications (3DES/SHA1)

Frame size (B)	Bi-dir throughput (IPv4) - Mbps	CPU utilization	Bi-dir throughput (IPv6) - Mbps	CPU utilization
64	2000	<2%	2000	<2%
128	2000	<2%	2000	<2%
256	2000	<2%	2000	<2%
512	2000	<2%	2000	<2%
1024	2000	<2%	2000	<2%
1280	2000	<2%	2000	<2%
1518	2000	<2%	2000	<2%

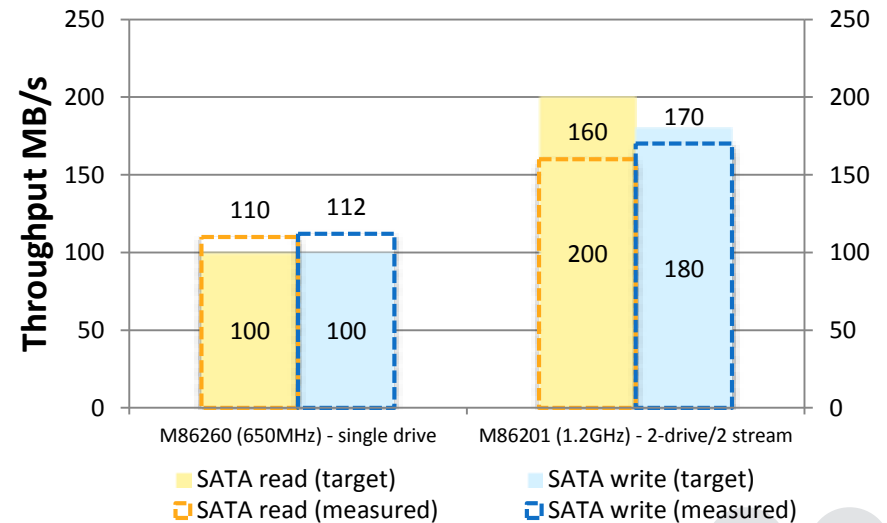
Line Rate performance with little or no CPU load on the A9

Concurrent 200Mbps of DPI upto L7

WLAN to Ethernet



CNAS: SAMBA Read/Write





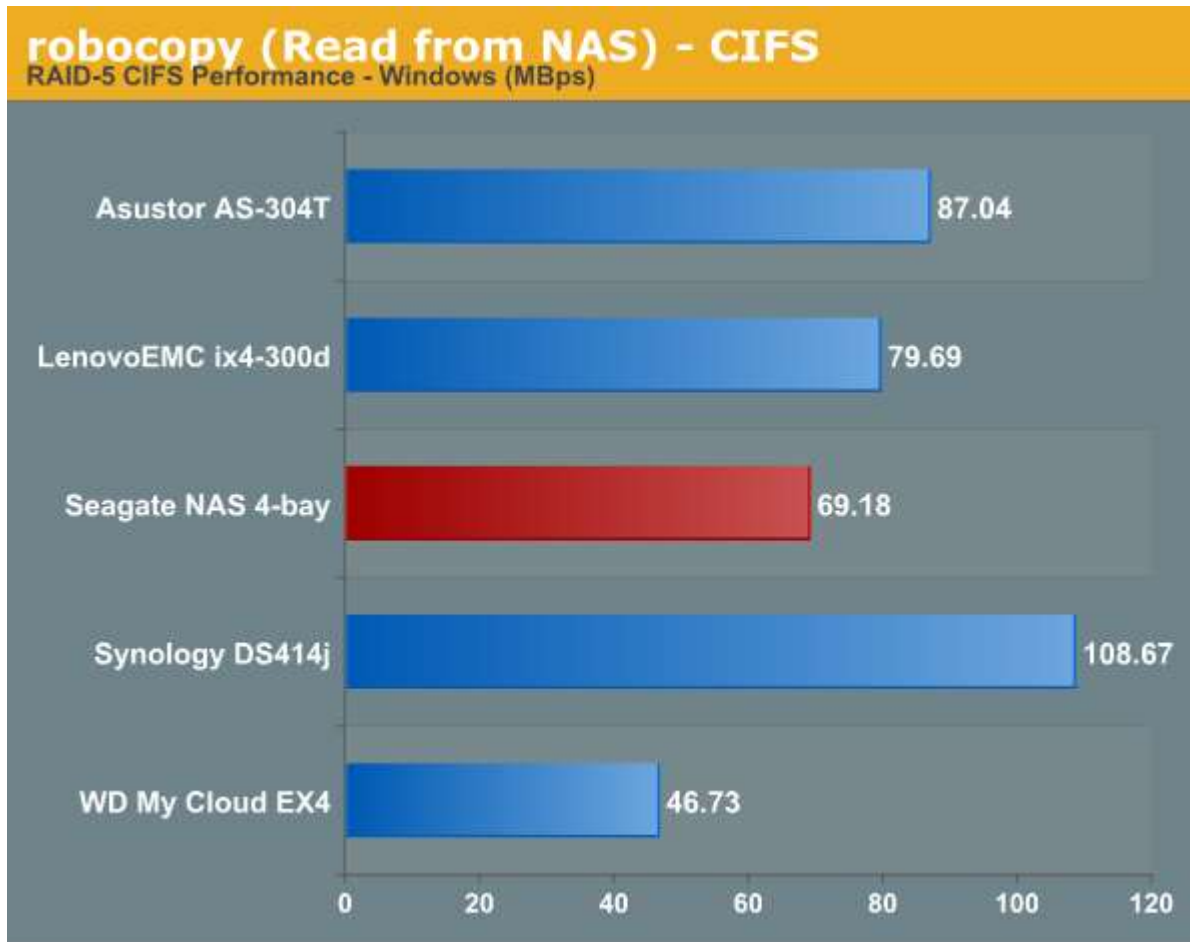
3rd Party NAS Benchmarks

Benchmarks Information

- Benchmarks taken from Anandtech.com review of Seagate 4-bay consumer NAS
- Complete review available at:
<http://www.anandtech.com/show/8264/seagate-armada-370-nas-4bay-review/3>



Robocopy Read (RAID5 configuration)



NAS SoC

Intel Atom 1.6GHz Dual-core,
Quad-thread

Marvell Armada XP 1.3GHz
Dual-core

Marvell Armada 37x
1.2GHz Single-core

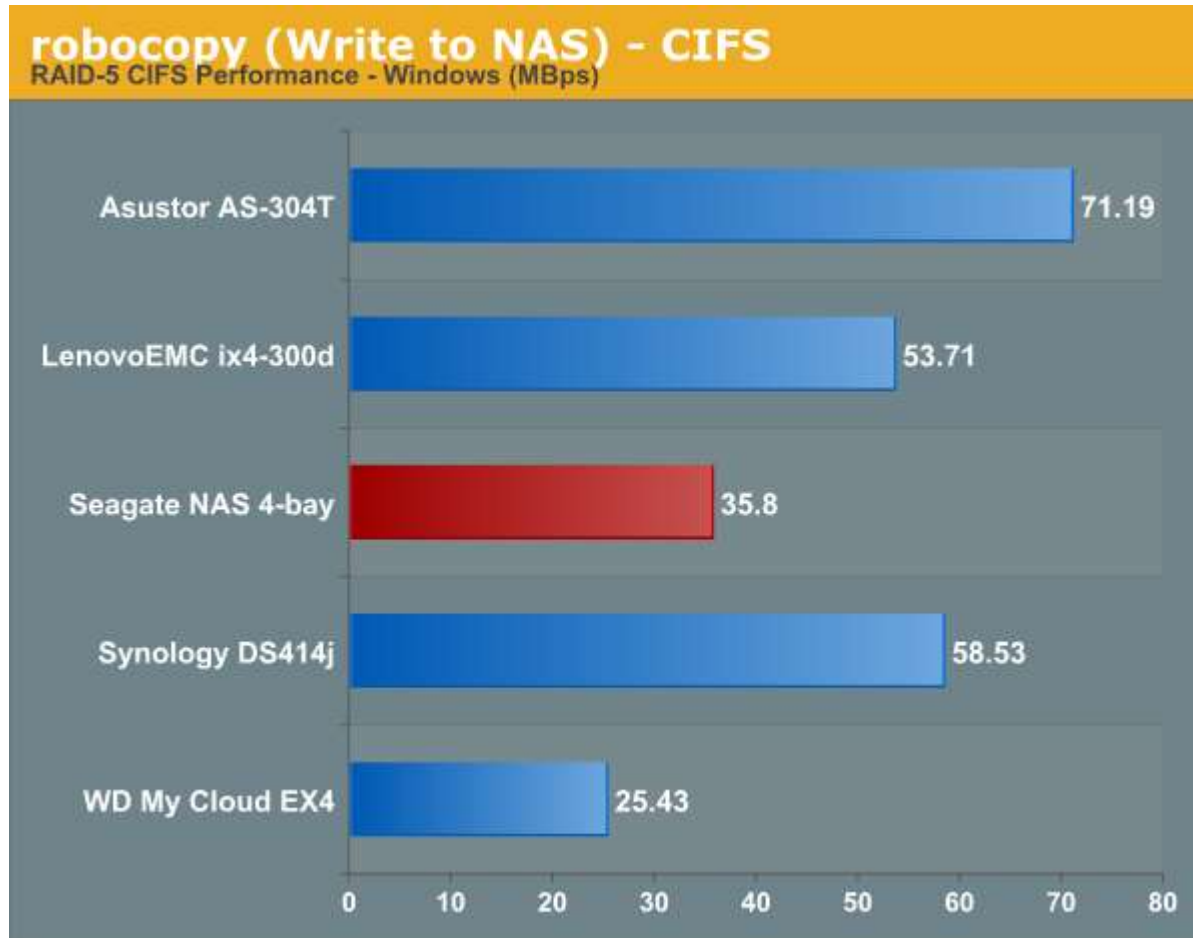
Freescale LS1024A 1.2GHz
Dual-core

Marvell Kirkwood 2GHz Dual-
core

- LS1024A outperforms Marvell based solutions, even higher priced devices
- LS1024A also outperforms much more expensive Intel chipsets on the read benchmark



Robocopy Write (RAID5 configuration)



NAS SoC

Intel Atom 1.6GHz Dual-core,
Quad-thread

Marvell Armada XP 1.3GHz
Dual-core

Marvell Armada 37x
1.2GHz Single-core

Freescall LS1024A 1.2GHz
Dual-core

Marvell Kirkwood 2GHz Dual-
core

- LS1024A outperforms Marvell based solutions, even higher priced devices
- LS1024A competes well with much more expensive Intel chipsets



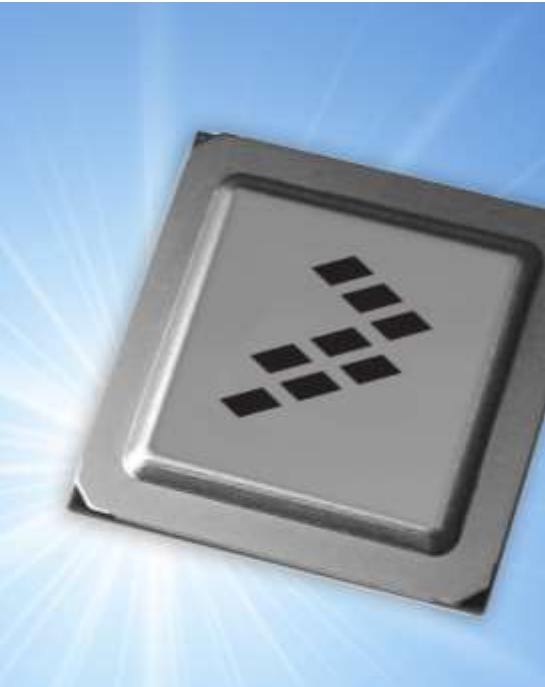


Roadmap and Summary



LS1024A NAS Solution Summary

Enterprise-class performance in a low-cost envelope



- Up to 7000 Coremarks CPU performance
- Hardware acceleration for security & packet processing
 - TCP Offload
 - Hardware XOR for RAID5
- Up to 2Gbps IP forwarding with <2% CPU load
- >100MB/s Read/Write performance
- Comprehensive Application Solution Kit SW speeds time to market



www.Freescale.com

ARM-based Options

	LS1021A	LS1020A	LS1024A	LS102MA
Core Type	ARM Cortex™-A7 MPCore™ + NEON		ARM Cortex™- A9 SMP/AMP + NEON with DSP and FPU	ARM1136J
Cores/Threads	2 / 2		2	
Frequency	Up to 1GHz		Up to 1.2GHz	Up to 650MHz
L1 I/D	32kB / 32kB with ECC		32kB /32kB	64kB / 64kB & 32kB DTCM
L2 (Unified)	512kB Shared with ECC		256kB	-
SRAM	128kB with ECC		64KB	128KB
DDR	1x(16/32B +ECC) DDR3L/4 up to 1.6GT/s		DDR2/3 (16/32B+ECC) up to 1066MT/s	
SerDes	4x up to 6.0GHz		3x	2x
Ethernet	3 x 1GE		3 x 1GE	2 x 1GE
PCIe	2 x Gen 2.0 (up to 5.0GT/s)		2x Gen 2.0 (5 GHz)	2x Gen 1.0 (2.5 GHz)
SATA	1x SATA 3.0 up to 6.0GHz		2x SATA 2.0 with RAID 0/1/5 CTRL	-
USB	1 x USB 3.0 and 1 x USB 2.0		1 x USB 3.0 and 1 x USB 2.0	1 x USB 2.0
CAN	Up to 4		-	-
Power Typ	2.8W		3W	2W
UART/I ² C/SPI	Up to 8 / 3 / 2		Up to 2 / 1 / 2	Up to 2 / 1 / 1
I ² S	Up to 4		1	-
LCD	1 x Controller	No	-	-
Acceleration	SEC,QE		PPFE, SE, DPIE, DECT	SE, 2 nd ARM used as PP
	Trusted architecture		Secure boot + Trustzone	-
	Pin Compatible 19x19mm, 0.8mm pitch		23x23mm 1.0mm pitch	21x21mm 0.8mm pitch



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