INTERNET OF EVERYTHING

WATER WORKS
Startup Droplet Inc. puts the low-power BCM2835 applications processor to work in its water-conserving robotic sprinkler.
Learn More

ENGINEERING A FIX
By engineering sensor and GPS technologies into a single chip, Broadcom is helping always-on mobile devices to improve accuracy and reduce power.
Find Out More

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PACKET OPTICAL NETWORKS AND SDN: WHAT MERCHANT SILICON ENABLES

Rajiv Ramaswami
Executive Vice President & General Manager, Infrastructure and Networking Group
ABOUT BROADCOM

2013 Net Revenue of $8.31 Billion

Founded in 1991

Initial Public Offering in April 1998 (NASDAQ-BRCM)

A Global Leader in Semiconductors for Wired and Wireless Communications

Broad IP Portfolio with More than 21,350 U.S. and Foreign Patents and Applications

One of the Largest Volume Fabless Semiconductor Suppliers

~12,400 Employees Worldwide
### Central Engineering Core Technologies (Custom Cell Libraries, Custom Memories, Analog and RF Building Blocks, I/O Cells)

<table>
<thead>
<tr>
<th>Data Center/Enterprise Switching</th>
<th>Service Provider Switching</th>
<th>Software Defined Networking</th>
<th>3G Baseband Processors</th>
<th>LTE Baseband Processors</th>
<th>Cellular RF</th>
<th>Cable STB</th>
<th>Satellite STB</th>
<th>IP STB</th>
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<td>Network Virtualization</td>
<td>Ethernet Copper PHYs</td>
<td>Ethernet Optical PHYs</td>
<td>Mobile Video Processors</td>
<td>Mobile Graphics Processors</td>
<td>Application Processors</td>
<td>Terrestrial STB</td>
<td>DOCSIS Cable Modem</td>
<td>Cable Head-End Processors</td>
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<td>Automotive PHYs</td>
<td>Optical Transport</td>
<td>Ethernet Controllers</td>
<td>Image Signal Processing</td>
<td>802.11 Wi-Fi</td>
<td>GPS/GNSS</td>
<td>ADSL/VDSL (CO/CPE)</td>
<td>EPON/GPON (OLT/ONU)</td>
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<td>Fiber Channel over Ethernet</td>
<td>Multicore Processors</td>
<td>Knowledge Based Processors</td>
<td>Bluetooth</td>
<td>NFC</td>
<td>Power Management</td>
<td>Powerline Networking</td>
<td>UltraHD/HEVC Processors</td>
<td>STB Graphics Processors</td>
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<td>SMB Processors</td>
<td>Backplane SERDES</td>
<td>Power over Ethernet</td>
<td>Touch Controllers</td>
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<td>IoT/Wearable SoC’s</td>
<td>Digital Transport Adaptors</td>
<td>Video Transcoders</td>
<td>STB Security Processors</td>
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<td>Energy Efficient Ethernet</td>
<td>Time Sensitive Networking</td>
<td>Microwave Backhaul Baseband/RF</td>
<td>Wireless Video</td>
<td>Location Based Services</td>
<td>MIMO</td>
<td>Small Cell Gateways</td>
<td>Satellite Outdoor Unit</td>
<td>Media Terminal Adapters</td>
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<tr>
<td>DFE</td>
<td>Deep Packet Inspection</td>
<td>Security Processors</td>
<td>Security Protocols</td>
<td>Enterprise Wi-Fi</td>
<td>Antennas</td>
<td>Video over Wi-Fi</td>
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<td>Infrastructure and Networking Group</td>
<td>Mobile and Wireless Group</td>
<td>Broadband Communications Group</td>
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</tbody>
</table>

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WHAT MERCHANT SILICON ENABLES? TRIDENT II DATA CENTER

Layer 2
- IEEE 802.1ah, PBB, PBB-TE, TRILL
- 1,2 VLAN TAG Translation Ingress/Egress
- FCoE, VnTAG, 802.1BR, 802.1Qbg
- L2 ACLs
- VLAN Cross-connect

QoS
- QCN, ECN, PFC
- 2 Level Hierarchy (3K Queues)?
- Single Rate and Two Rate
- Three Color Marking and Policing
- WRED

Interfaces
- 106 x 10G
- 32 x 40G
- Link Aggregation
- Jumbo Frames to 12K

Layer 3
- IPv4, IPv6 Unicast / Multicast
- Ingress, Egress ACLs
- Policy Based Routing
- Flex Hash, Resilient Hash, Symmetric Hash
- Dynamic Load Balancing
- NAT / PAT

MPLS
- LSR, LER, PHP
- RFC2547 L3 VPNs
- MPLS TE, FRR
- MPLS-TP
- MPLS DiffServ
- MPLS VPLS, EoMPLS, H-VPLS
- Pipe, Short Pipe, Uniform QoS

Tunnels
- VxLAN, NVGRE
- GRE, IPv6

More Features
- Traffic Monitoring
- SPAN, RSPAN, ERSPAN, sFlow
- 1588v2 1 Step & 2 Step, SYNC-E
- IEEE 802.1AS
- Ethernet OAM
CHANGING HOW DATA CENTERS ARE BUILT

Physical Static Servers
Tiers of Servers
Single-tenant Data Centers

Designed for North-South Traffic and N-tiered Data Center

N:1 Oversubscription

Flat Network Topologies with Modular Horizontal Scaling and Full Cross-Sectional Bandwidth

Virtual Machines and Mobility
Any Application on Any Server
Multi-tenant Data Centers in Clouds

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Fixed Systems
Industry's densest Ethernet switching solution

- 16 x 40G, 64 x 10G
- L2 PBB, PBB-TE
- L3 IPv4 IPv6
- MPLS LSR, LER

Modular Systems Line Card Devices (TM/PP/FIC)
Industry's densest Ethernet switching solution

- 10/20G
- 100G BW
- Integrated Packet Processing
- IPv4/IPv6
- MPLS, L2/L3 VPNs

- 32 x 40G, 106 x 10G
- L2 PBB, PBB-TE
- VxLAN, NVGRE
- MPLS LSR, LER

- 32 x 40G, 106 x 10G
- L2 PBB, PBB-TE
- VxLAN, NVGRE
- MPLS LSR, LER

- 240G BW
- 10/40/100GE, Interlaken
- OTN, OAM

- 2x Increase in BW
- New features

- 2x Increase in BW
- 2x Increase in Tables
- New features

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NETWORK CHALLENGES

Packet Services
- Bursts of packet traffic
- High QoS
- Majority IP Traffic

Reliability
- Real time
- Highly reliable transmission

Bandwidth
- Efficient transport of IP services
  - Video conference
  - Video surveillance

Cost Effectiveness
- Simplify OAM
- Lower power/bit
- Lower cost/bit

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TRANSPORT NETWORK EVOLUTION

- Designed for TDM and voice
- One wavelength per fiber

- Multiple wavelengths per fiber
- Complex and big overhead to carry Ethernet
- Proprietary methods for mapping, performance monitoring and fault detection

- Standard network arch (G.872) and mapping (G.709)
- Standard multiplexing hierarchy
- End to end path monitoring
- Standard FEC
Core Simplified

- Massive Bandwidth
- Aggregate QoS
- Intelligence in DC and Edge Router
OEO conversion: core network evolution

- Three steps are envisaged in the core network evolution:
  - Assume two connections: A → B and A → C

Currently:
- IP/MPLS
- SDH
- OTN (sub-λ)
- WDM mesh
- IP hops at intermediate nodes ⇒ OEO conversion + packet processing.
- High IP-router port count.

OTN offloading:
- IP/MPLS
- SDH
- OTN (sub-λ)
- WDM mesh
- EOE conversion at intermediate nodes.
- Transponders at each node.

IP offloading:
- IP/MPLS
- SDH
- OTN (sub-λ)
- WDM mesh
- All-optical, elastic (sub-λ) routing from source to destination nodes in a transparent way.
TERASTREAM – DESIGN IN A NUTSHELL

Source: TeraStream – A Simplified IP Network Service … – RIPE 67
TYPICAL P-OTS/P-OTN/LEAN CORE SYSTEM

- Scale to 1000s of 100G ports
- Single Fabric or Multi-Fabric Planes
- Single Chassis or Multi-Chassis Supported
- Flexible Packet Processing
- Hierarchical Queuing
- Table extension with KBPs
ENABLING THE NEXT GENERATION OF 100G/400G DSP ASICS

100G Technologies
- CD Compensation
- Polarization Control
- SD-FEC
- Evaluation
- Modulation
- ADC
- Line Estimation
- DSP Algorithms

High-performance DSP

Current 100G DSP

Low-power, Compactness

Performance (Transmission Distance)

Spectral Efficiency (Number of Wavelengths)

400G Level Technologies
- Adaptive Modulation
- Linearizer
- Nonlinear Compensation
- DAC
- Ultra-gain FEC
- Power Control

100G Technologies

Eco Technologies
- Power Gating Control
- Datacom Applications

100G Technologies

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SDN and NFV
Spans Physical Network Layer, Network Services, SDN and NFV Platforms

- Enabling **dynamic** provisioning, **faster** innovation and deployments
- Enabling performance and **scale for all workloads**
- Cloud Scale blueprint for **Efficient** network design
Open reference design, Open NFV Platform, OpenFlow 1.3.1 reference design on Github

OVS acceleration, NFV acceleration, service chaining,

OpenFlow-Data Plane Abstraction (OF-DPA) 1.3.1, OVS offload

Future proofed support for emerging protocols for SDN/NFV

Hardware based network virtualization, overlay aware load balancing
Tight Partnership with Cisco to Deliver Leading Platforms

- Scale, functionality, consolidation, feature velocity
- Rapid TTM for system providers, reduced R&D costs
- Open development ecosystem for SDN and NFV
Thank You