Managing Data Center
Power & Cooling

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Agenda

- Data Center Power Crunch
- Strategies for Reducing Power Across IT
- Power Efficiencies in Networking Today and Moving Forward
- Customer Case Studies
- Q&A
Until recently power efficiency in the Data Center has not been paramount in IT rollouts.

This is now changing and is being driven by:

- Rising power costs
- Blackouts/Brownouts and capacity planning
- Limits to grid/sub-station scaling (No more power available)
- Politic pressures and “green” legislation to drive greater data center efficiencies

If we as an industry don’t lead the process we will be dragged to an unacceptable position.
Energy & Power

- **Energy**
  - Joule (J)
  - Watt-Hour (Whr)
  - Kilowatt-Hour (KWhr)
  - British Thermal Unit (BTU)

- **Power – rate of use of energy**
  - Joule/second
  - Watt == Joule/second
  - Kilowatt = 1000 Watts
  - BTU / hour
  - 1 Watt == 3.413 BTU/hr
  - Ton (usually = 12,000 BTU/hr)

**Analogy:**
- Gallons of water
- Gallons/hour = rate of use of water
**Data Center Crisis: Power/Cooling**

**Moore’s Law: More Transistors…**

**More MIPs… More Watts… More BTUs**

1 watt of power consumed requires 3.413 BTU/hour of cooling to remove the associated heat

**Data Center Power Density Went from 2.1 kw/Rack in 1992 to 14 kw/Rack in 2006**

**3 Year Costs of Power and Cooling, Roughly Equal to Initial Capital Equipment Cost of Data Center**

**63% of 369 IT professionals said that running out of space or power in their data centers had already occurred**
Growing Power Density

- Communication - Extreme Density
- Compute Servers - 1U, Blade And Custom
- Compute Servers - High Density
- Compute Servers - 2U And Greater
- Storage Servers
- Workstations (Standalone)
- Compute Servers (equipment, Standalone)
- Tape Storage

Year of Product Announcement

Heat Load Product Footprint (watts / equipment sq. ft.)

Growing Power Density

Culprit or Savior?

Brave New
World of >15 KW per sq foot
Force10 Customers
Data Center Power Considerations
1. Prime mover in budgets
2. Network 10% of power budget… **Biggest relief by increasing density and utilization**
3. From planning to build >12 months
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Total system efficiency comprises three main elements - the Grid, the Data Centre and the IT Components. Each element has its own efficiency factor - multiplied together for 100 watts of power generated, the CPU receives only 12 watts.

So the “other way” and saving 6 watts means reducing 60 watts of power plant generation.
A Series of Conversion Efficiencies

- **Fuel Source**
- **Carbon Conversion factor**
- **Renewables**

**Server Utilisation**
- Operating System Efficiency
- Software Optimization

**Grid**
- Data Centre
- IT Components

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A Series of Conversion Efficiencies

Carbon Efficiency

Fuel Source
Carbon Conversion factor
Renewables

Server Utilisation
Operating System Efficiency
Software Optimization

Grid Data Centre IT Components
A Series of Conversion Efficiencies

Carbon Efficiency
- Fuel Source
- Carbon Conversion factor
- Renewables

Grid Efficiency
- Server Utilisation
- Operating System Efficiency
- Software Optimization

IT Components
- Grid
- Data Centre
- IT Components
A Series of Conversion Efficiencies

**Carbon Efficiency**
- Fuel Source
- Carbon Conversion factor
- Renewables

**Grid Efficiency**

**Data Centre Efficiency**

**Server Utilisation**

**Operating System Efficiency**

**Software Optimization**

**Grid**

**Data Centre**

**IT Components**
A Series of Conversion Efficiencies

- **Carbon Efficiency**
- **Grid Efficiency**
- **Data Centre Efficiency**
- **IT Efficiency**

**Fuel Source**
- Carbon Conversion factor
- Renewables

**Server Utilisation**
- Operating System Efficiency
- Software Optimization

**Grid**
- Data Centre
- IT Components

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A Series of Conversion Efficiencies

- Carbon Efficiency
- Grid Efficiency
- Data Centre Efficiency
- IT Efficiency
- OS/Software Efficiency

- Fuel Source
- Carbon Conversion factor
- Renewables

- Server Utilisation
- Operating System Efficiency
- Software Optimization

Grid | Data Centre | IT Components

- Power Station
- Transmission
- Transformer
- Cabling
- Cooling
- Ancillary
- UPS
- S/S
- Power supply
- DC/DC Conversions
- CPU
Data Center Best Practices

- Majority of efficiency improvement from rectifying inefficient cooling (60% of your wattage work set)
- Hot/Cold Row Cooling
- Minimize leakage/blocking/bypasses
Tips

- Stay diligent about hot and cool aisle flow
- Ruthless air flow… watch out for cabling, other obstructions.
- Blank your racks as well as your slots
- How cool? --- the mid-point of recommended range is 74 degrees and 50% humidity
- Get your tiles rights… perforated for cold, solid for hot
- Read your electric bill.

Minimize power consumption and maximize power efficiency at every level within the infrastructure.

- CPU Chips
- Power Supplies
- Servers
- Storage Devices
- Cabling
- Networking
Power efficient architectures
- A dual core processor can deliver >60% higher performance than a single core processor dissipating the same power
- e.g. integrated memory controllers
- Application-specific multi-core chip architectures include cluster computing, transaction processing, and multi-tasking.

Processor Power Management with Dynamic Clock Frequency and Voltage Scaling (CFVS)

Future: Transistors with Lower Leakage Current
- replace the silicon dioxide gate dielectric with hafnium-based high-k material
Clock Frequency and Voltage Scaling

- Dynamically adjusting CPU performance (via clock rate and voltage) to match the workload
- Uses the operating system’s power management utility via industry-standard Advanced Configuration and Power Interface (ACPI) calls
- 75% power savings at idle and 40-70% power savings for utilization in the 20-80% range
Blade Servers:
- Chassis “sharing” can reduce power consumption by 20-50%
  - Larger chassis’ are more efficient (>80%)
  - Blade servers inspired by modular switch/routers
  - Even esoteric edge improvements scale up

Server Virtualization:
- Applications consolidated on a smaller number of servers, eliminating power consumption by many low utilization servers dedicated to single applications
- Potentially #1 improvement (5-20x “compression”)

![Diagram of server virtualization](image)
Power consumption in storage devices is primarily by spindle motors and is largely independent of the capacity of the disk
- The bigger the disk, the better

Maximize TBytes/watt to the highest capacity disks
- Must keep I/O characteristics compatible with the applications being served

Unified Ethernet storage virtualization technologies and large-scale tiered storage maximize power efficiency by minimizing storage over-provisioning
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Little difference in Gbps/watt for fixed configuration and stackable switches

Considerable differences for modular switch/routers due to backplane technology and box-level densities

- Heavy copper traces reduce backplane resistance and wasted power consumption
- Force10 E-Series uses patented 4 layer, 4 ounce copper backplane that has power efficiency of 4.5 Gbps/watt (= backplane capacity/power consumption)
- 10-20x less resistance
- Ethernet can provide LAN connectivity, storage networking, and cluster interconnect across the data center

- With a unified fabric, power is conserved
  - No additional sets of switches for specialized fabrics
  - Higher utilization on existing switches
  - Only one network adapter per server
  - Efficient cable management
Applications draw on a shared pool of resources

No resources dedicated to a single application – higher utilization

Workloads of various applications peak at different times in the business cycle

Shared resource model: Do the same job with far fewer resources
System configured with **full switch fabric, route processor, and power redundancy** and 672 **line-rate** GbE 1000 Base-T ports

<table>
<thead>
<tr>
<th>Slot</th>
<th>Watts</th>
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<tbody>
<tr>
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<td>1,055</td>
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<tr>
<td>1</td>
<td>290</td>
</tr>
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<td>13</td>
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</table>

**Total Power** 5,365 Watts

**Power Efficiency in Watts/Gbps** 8 (=5365/672)

**DC Current @ 40V** 134
Maximizing Network Power Efficiency

In the Core and Data Center

- E-Series resilient, scalable, high density switches
- collapsed Distribution/Access Tier--2-Tier switching
- elimination of numerous low density switches

Power Saved on 270 Node DC

<table>
<thead>
<tr>
<th>2 Force10 E1200s</th>
<th>5 Catalysts 6000s</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,600 watts</td>
<td>20,000 watts</td>
</tr>
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</table>

Source: Enterprise Rental Car
Maximizing Network Power Efficiency

In the Wiring Closet
- C-Series resilient, scalable, high density wiring closet switches
- Collapsed Distribution/Access Tier--2-Tier switching
- Eliminate numerous low density switches

<table>
<thead>
<tr>
<th>Comparison – Large Campus</th>
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<tbody>
<tr>
<td>C-Series</td>
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<tr>
<td>3</td>
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<tr>
<td>9,400 watts</td>
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Introducing the Force10 S2410

Highest Density, Lowest Latency and Price

- Industry-leading density and flexibility
  - 24 line-rate 10 GbE ports in 1 RU
  - Full function switch
  - XFP or CX4 interfaces

- Drives down 10 GbE port prices to spur adoption
  - List pricing starting at $24,000 (CX4)
  - Reduces 10 GbE switching latency to InfiniBand levels
  - 300 nanoseconds

Lowest power consumption of any switch on the planet
480 Gbps switching on 125 watts!!!
Becoming a key metric for product comparison
- Servers: Application workload/watt (e.g., Mflops/watt)
- Storage: GBytes/watt
- Networking: Gbps/watt

IEEE Energy Efficient Ethernet working group

EPA considering Energy Star Rating for Data Center equipment, including switch/routers

Force10 member of TheGreenGrid.org and can provide updated power calculators to model power and cooling in TCO calculations
Timing of Application Needs

<table>
<thead>
<tr>
<th>Date</th>
<th>Rate Mb/s</th>
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<tbody>
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<td>1995</td>
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<tr>
<td>2000</td>
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<tr>
<td>2015</td>
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<tr>
<td>2020</td>
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Source: IEEE 802.3 HSSG
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Remove Wasteful Interconnects

**CAP-EX**
- 75% lower up front cost, > $1 million savings
- One device, versus five
- 28 less line cards

**OP-EX**
- 81% less power
- 81% less cooling needed (air conditioning)
- 80% less rack space

**OP-EX**
- Power 3,760 W
- BTU / hr 12,812

**OP-EX**
- Power 19,920 W
- BTU / hr 67,960

4 x 10 GbE uplinks

270 line-rate nodes

48 x 10 GbE Interconnects

90 270 line-rate nodes
**Client Requirements**

- Build #1 super computing center in Europe to focus on computational, earth and life sciences
- Location - Torre Girona Chapel
- 153 sqm with 2,560 GbE nodes - 94.21 tera flops
- Non-blocking supercomputing
- Create a scalable, flexible environment

**Solution**

- Raised floor to accommodate high flow reqs
- Cooling water storage tanks
- IBM blue gene and 1350 blade servers drove massive Gigabit densities

**Benefits**

- High density Ethernet (8 watts/gbe)
- Supports 21KW/rack (400 W/sq ft) of cooling
- Flexibility for the future –supercomputing performance upgrade underway
- World’s most beautiful supercomputing center
Yahoo! Case Study

Client Requirements

- Bandwidth doubling every year
- Expects 10 GbE server scale in 1-3 yrs.
- 20 Gigabit bandwidth in metro transport
- Explicitly dual-vendor – interoperability a must

Solution

- Running 80 KM WDM optics
- “POD” design with 300+ GbE nodes
- Extreme Gigabit densities

Benefits

- Power footprint of 2.5 KW per 300 nodes
- 1/3 the cooling budget of previous switch and over $2.5M in power & cooling savings in 3 years
- Substantial (4-8x) saving over SONET
Based on standard U.S. Government tests

ENERGYGUIDE

Router Switch

Compare the Energy Efficiency of This Switch-Router with Others Before You Buy
Thank You

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