Data Center Connection Design Technologies - Stop Doing What You are Told

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Background Info

• Review to some, new to others
• There is NO one size fits all
• There is NO one size fits all in a single site
• New data center types are coming online
  • Hyperscale
  • Edge
  • Core
  • Colo,
  • Etc.
Roll as a Facility Manager

- Referee
- Gatekeeper
- Babysitter
- Stepchild
- May have more responsibility than authority
- “I put in what I’m told”
What the Facility Manager Should Be

• Advocate
• Devil’s Advocate
• Consultant
• Active participant
Outages

• Delta Cancels 280 Flights Due to IT Outage (Jan 2017) second outage in 6 months $170 M
• 150M from August outage
• More than 200 United Airlines flights were affected by an IT outage on January 29
• An outage at Southwest in July was estimated to have cost the airline at least $177 million
• JetBlue, United, BT, China Air
Outage Costs

- Tangible
- Intangible
- Average cost $730,000
- Highest reported cost in 2016 $2.4M
Downtime Costs

- Employee Salaries Weighted
- Revenue / Number of employees / Hours worked
- Costs to recuperate
- Costs to repair
- Damage control
- Reputation
- Overtime for personnel to fix and secure a site
- Time to triage the problem
- Time to update DR plans and test
STUPID HUMAN TRICKS

I want to buy a fog machine and put it in a data center

So when I open the door, fog spills out, I can say "Welcome to THE CLOUD!"
STUPID HUMAN TRICKS

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So when I open the door, fog spills out, I can say "Welcome to THE CLOUD!"

WARNED UPPER MANAGEMENT REPEATEDLY FOR OVER A YEAR ABOUT TOTAL IT FAILURE. DENIED FUNDING EVERY TIME.

THIS WEEKEND THE SERVER ROOM WENT DOWN. COMPANY AT STANDSTILL. THEY BLAME ME.
Redundancy

Facilities
- UI
- BICSI
- TIA
- ISO
- IEEE
- Engineers

IT
- Software Fail over
- Hardware Failover
- Redundant data
- Virtualization
The Anatomy of a Data Center
Impacts of the Pieces and Parts

- Power
- Cooling
- Water
- Networking
- Servers
- Storage
- WAN
- Security
- Wireless (yes)
- Pathways and spaces

Budget
Lengths (Lengthonomics)
Locations
Influence
Operating Costs / Capital Costs
Maintenance
Fabric Layout with 10GBASE-T.....
Edge to Core is Essentially This
What the Server Team Sees

I NEED........
Can I have this yesterday, please?
They think in terms of virtual machines and % of virtualization.
CPU Utilization sometimes...
Power consumption of servers...ish

Number of network ports, number of storage ports, number of power ports, number of management ports
What the Networking Team Sees

End of Row
- Fewer Switches
- Fewer uplink ports
- Lower power
- Purchased 12288 used 7680

$44,402 Annual Power Cost

Top of Rack
- More switches
- Probably more unused ports
- More uplinks
- More uplink switch ports
- More power
- Purchased 4608 – used 4608

$101,419 Annual Power Cost
What the Storage Team Sees

- Ports per server
- Backup ports
- Backups
- Where it sits?
- Deduplication strategy
- Disks?
- SSD?
What the Facilities Team Sees
What an Application Sees

• Failover from Server to Server
Multiple Sites with Failover
The Reality

• Every application needs hardware
• All hardware must live in the same space
• Hardware is connected to other hardware
• Hardware draws energy
• Silos lead to bad decisions
When Applications Fail Over One Server to One Server

- Each Application is Backed by
  - 4 Network Connections
  - 4 Power supplies
  - 4 Storage Connections
  - Mirrored Management Connections
Costs

• Tier IV is higher than other tiers by a significant margin
• Cost per square foot rental is higher in upper tier data centers
• Large market of people that are willing to co-op their extra DC space
• Purpose is important
• New tax laws make OPEX less of a benefit
• Power and stranded power are a continuous problem
• The cost of a server doubles in 18 months due to power costs
Tangible Costs

- Additional Network Ports
- Additional Switches
- Addition PDUs
- Increased Cooling Demand
- Additional Power
- Additional Additional UPS capacity
- Increased Generator requirement
What are We Really Supporting in a DC?

• Applications for Business
• Business Data
Time to Step Back

• What do you really need?
• Who is making the decision
• 5-Why’s
• Stop making decisions in a vacuum
• Top down matters
• Real estate may not understand DC contracts or needs
How do Colo Contracts Get Negotiated?

• Needs during the contract period
  • Facilities
  • IT
  • Finance
  • Real Estate
  • Brokers
New Accounting Rules

• Beginning in 2019 Lease costs must be reported on the balance sheet.

• This includes operational costs (OPEX) lease costs.

• Expected to have a $3 Trillion impact on balance sheets alone

• Likely to change colocation lease agreements
Surprises

- New rules require you to disclose the full lease obligation regardless of the amount of capacity that you use.

- Ramp up periods don’t matter
A Better Measure....

• Start at the application
• Understand that all applications are NOT alike
• All applications will not have the same needs
IT Factors to Consider

• Connectivity
• Waste
  • kW per cabinet
  • Reach of connections
• Lifecycle
• Location
  • More applications to the cloud
• Software defined EVERYTHING
Healthier Way to Start

- Application
- Redundancy
- Server
- Network
- Power
Application

• Risk – What happens if it goes down?
• How to mitigate that risk?
  • Additional Server
  • Failover
  • Site to site failover
  • Manual
  • Edge
  • Additional Communication Lines
  • Cloud
• What is necessary to keep it running?
Risk Level Things to Calculate

• Catastrophic Failure to low risk
• Time to recover
• Time to repair
• Security risks
• Job risks
• Power
• Cooling
• Building
Server Cost Multiplier

- Cost of server (hardware and virtual)
- Cost of software and licenses
- Cost of network ports
- Cost of power ports
- Cost of storage ports
- Allocated cost of switches
- Allocated cost of storage
- Allocated Security
- Cost of power
- Building capital, rent and leases
Who to Involve

- IT
- Department Heads
- CIO/CTO/CDO
- Security
- CEO – Top down is key
IT Resources

• Ethernet Alliance
• IEEE
• FCIA (Fibre Channel Industry Association)
• Peers
• MOOC
Strategies for Evaluating Different Solutions

• You don’t have to know it all
• You do have to make your vendors work for you
• Sole sourcing can be dangerous
• Purpose built solutions can hinder growth and be expensive
• Be wary of solutions where you have to throw the baby out with the bath water
Why Use “Or Equal”

• Allows substitution of like products
• Allows alternate vendors and integrators to respond
• Opens the specification for greater competitive bidding
• Many consultants see this as their “value add”
• Perceived as an equalizer
• Stops sole sourcing
• Is greatly ignored (lip service)
What Exactly is “Or Equal” Technology

• All products have some unique feature
• All vendors have support personnel
• A balanced scorecard can provide a better means of evaluation
• Understand the value of the unique features

• If it’s standards compliant, it’s standards compliant!
• Features are nice buy only if they really do something
Unique Features

• What is the value of the feature?
  • Is it a nice to have? Or is it a must have?
  • Is it used to circumvent fair and equal bidding?
• Do you have a full understanding of this feature?
• Could you evaluate bids based on this feature?
• Can IT fully articulate this feature?
• Has it been vetted?
Selective Text...Examples

• Lower Power consumption
  • Is this true for the entire communication chain or is it just one port?
  • Is this a constant feature or only during certain conditions?
  • Is this claim independently verified?
  • Does it matter?
  • Can something else do it better?

Mom, can I have a huge bowl of ice cream smothered in chocolate?
Anatomy of a Ball

• Part of the UEFA Champions League Collection 1:1 take down in color and panel design from the Official Match Ball
• Machine stitched construction and internal nylon wound carcass for maximum durability and long-lasting performance
• Butyl bladder for best air retention to keep the ball's shape and stay inflated longer, and Special TPU exterior material is designed to resist abrasion and last longer
• 2016 colors have revolutionary tonal printing on ball for extra pop and style
• Size 3 ball suggested for ages 8 and under; size 4 ball suggested for ages 8-12; size 5 ball (official size) suggested for ages 12+. Size 1 is a mini ball. Check with your local league for size requirements.
Is This Ball Better?

- Alternating dark and light color scheme allows you to see ball better when it rolls around the pitch or comes at you in the air
- Butyl bladder of 380-420g inside keeps everything together and inflated properly
- Ball comes in size 5 for ages 12 and above
- Exterior is made of 2.5 mm PVC which resists abrasion and makes the ball more durable
- Machine stitching keeps the panels together on this typical soccer ball and give a soft feel
What About This One?

- 32-panel design for durability.
- Machine-stitched TPU casing for consistent play.
- High-contrast graphics for easier visual tracking.
- Reinforced butyl bladder increases the speed off the foot and enhances air and shape retention.
- 60% RUBBER 15% POLYURETHANE 13% POLYESTER 12% EVA
What Technical Specs

- 12 to 20 panels some premium-grade 32-panel balls
- The ball's panel pairs are stitched along the edge; manually or by machine
- The size of a football is roughly 22 cm (8.65 inches) in diameter
- The ball's weight must be in the range of 410 to 450 grams (14 to 16 oz) and inflated to a pressure of between 0.6 and 1.1
What Actually Matters?

• Quality of the ball
• Color of the ball
• Stitched construction
• Material of the ball
• Use case
How many balls are there?

• 119,864 on Amazon®
• Which specification matters?
• Which parameter matters?
• If someone’s bid says they meet that spec can you verify it?
• And the biggest question.....Can you trust your experts to know the difference?
What do standards provide?

• Least common denominator
• Fair and impartial
  • Compliant
  • Compatible
• In IT they are pretty much the law
• IEEE, TIA, ISO/IEC, ANSI/TIA/EIA, FCIA
• COMPLIANCE IS KEY!
What does Compliant Mean?

- Means that the product complies to all requirements of the standard
- Products can exceed, but should at minimum comply
- Proprietary products won’t be compliant, but may be beneficial
- Interoperability (or lack thereof) introduces risk
Exceeding the Standards

• New materials for longer channels
• Tranceivers
• Extenders
• More centralized switch locations (yes we used to)

<table>
<thead>
<tr>
<th>Option A</th>
<th>Option B Cat6 with Port Extenders</th>
<th>Option C With Extenders &amp; Transceivers</th>
<th>Option C Without Transceivers</th>
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<td>$22,305</td>
<td>$104,525</td>
<td>$126,170</td>
<td>$116,934</td>
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</table>
Vendor Backstories are Telling

• Do they create standards compliant products?
• Can your IT department defend why they have to have a non-compliant product?
• Do you purchase the standards to know what they contain?
• Do you ask for interoperability testing?
• Do you test yourself?
• Will they help with testing?
What You Should Ask IT

- Why does this spec matter?
- What will the “or equal” statement do to this bid?
- What parameter is a competitor not likely to be able to match?
- Why is that specific parameter important?
  - Don’t let them blow smoke
- What would happen if that couldn’t happen?
Understanding the Supply Chain

• Who manufactures the product?
• Trends are towards outsourced/contract manufacturing
  • Less expensive
  • Controls are in place to assure quality
  • Tax breaks for various world regions
• REBATES
• Who is influencing the decisions on your end?
• Relationships
Set Up Vendor Interviews

- Gut check and fact check
- Understand the difference between belief and reality
- Nice to have is not necessary
- Ask for alternates to your idea!
Sphere of Influence

- Who touches the product?
- What is the difference between a sourcing distributor and a stocking distributor?
- What processes are in place to assure stock?
- What is the alternative brand if stock is not available?
- What is the availability of the alternative brand?
- Did you get bids on that brand?
- Is it in fact "or equal?"
Who do you ACTUALLY pay?

• Understand mark-up
• Is it worth adding another vendor?
• Find the right test
  • Dollar to donuts so to speak
  • It is worth it if it saves xxxxx
• Hard specifications often carry higher pricing
• Social consciousness
What is the Real Value?

• Understand what is in every dollar
• Do you need the $184 ball, or would it be just as good to kick the $12.99 one?
• Is the value perceived or tangible?
• Who will use the ball?
• What is the expected life of the ball?
• Are features necessary or “want to”
• Ask yourself, “If I could keep 10% of the savings, would it be worth it?”
Buying a Soccer Ball

- Ball is manufactured by xyz
- Sold to store A
- Store A has a storefront on site B
- Site B collects sellers fees and advertising fees
- Site B maintains stock (some risk)
- Site B makes it easy to find the ball (convenience)
- Site B provides a front end order entry/payment processing service
- Would you wait a day or two to save?
Should You Buy From A or B?

- What is the convenience worth to you?
- What if they can’t meet delivery?
- What if it arrives and is damaged?
- Who resolves the complaint?
- Would holding some stock at our own place be cost effective?
- *If you wait until the last minute you limit your options!*
Top Tips

• Create a score card
  • Use it for bid evaluation
  • Use it as follow up evaluation
  • Before, during and most importantly
• AFTER
  • How did they support the team?
  • How did they support the business needs?
  • Were their claims true?
  • Did they follow through?
Procurement Specific

• No one is an expert at everything
• People hate change
• Who are you to question my decision?
Steps for success...

• Do an RFI first!
• Tell your vendor it will be an open spec
• Encourage options
• Have vendor interviews
• Ask one vendor about features of others
• Ask how they go to market
• Ask if they provide direct pricing
• Ask independents for help
In a Perfect Data Center World...

- Budget Silos would not exist
- Reconfigurations would not be required
- Updates would not be required
- Decommissioning/Commissioning would be easier
- Vendors would cooperate
- Open systems would reign
- Vendor Lock-in would not exist
- Power and cooling would be easier to manage
- Vendors would have your best interests at heart
- The data center floor would remain stable
Understanding the Data Center Ecosystem

• Data Centers Include
  • Power
  • Cooling
  • Cable plant
  • Servers
  • Switches
  • SAN/storage
  • Wide Area
  • Overall room systems/monitoring
  • Miscellaneous systems
Why do we care?

• The data center is an ecosystem
• The more equipment we add, the more power we consume
• The more power we distribute, the more losses we have
• The more power we consume, the more cooling we need
• The more cooling we need the more power we need
• The more power we need the more $$$$$$
• Power is about 50% of the data center ongoing costs
Things That Impact Power

- Number of powered devices
- Number of redundant connections
- Air movement
- AC versus DC
- Stranded/phantom power
- Room arrangement
- Equipment arrangements
- Allocations (may not be the same across the DC)
Rating/Tier® Level

ANSI/TIA-942 describes four Rating/Tier® levels in which data centers can be classified. Below is the high level description of each Rating/Tier® level. Detailed specifications are given in the ANSI/TIA-942 standard.

- **Rated-1/Tier-1**: Basic Site Infrastructure
  A data center which has single capacity components and a single, non-redundant distribution path serving the computer equipment. It has limited protection against physical events.

- **Rated-2/Tier-2**: Redundant Capacity Component Site Infrastructure
  A data center which has redundant capacity components and a single, non-redundant distribution path serving the computer equipment. It has improved protection against physical events.

- **Rated-3/Tier-3**: Concurrently Maintainable Site Infrastructure
  A data center which has redundant capacity components and multiple independent distribution paths serving the computer equipment. Typically, only one distribution path serves the computer equipment at any time. The site is concurrently maintainable which means that each and every capacity component including elements which are part of the distribution path, can be removed/replaced/serviced on a planned basis without disrupting the ICT capabilities to the End-User. It has protection against most physical events.

- **Rated-4/Tier-4**: Fault Tolerant Site Infrastructure
  A data center which has redundant capacity components and multiple independent distribution paths serving the computer equipment which all are active. The data center allows concurrent maintainability and one (1) fault anywhere in the installation without causing downtime. It has protection against almost all physical events.
What’s Wrong with Redundancy

• Address critical facilities and paths
  • Power
  • Cooling
  • Transfer Switches
• Addresses some level of uptime expectation
• Ignores circuits for IT
• Ignores the application and failover expectations
• Ignores the IT side of things
Data Center Power

• Don’t assume that teams will select the most power conscious equipment
• Challenge what you see
• Be a smarter consumer

• AVOID CAPACITY PROBLEMS THROUGH UNDERSTANDING
Support Systems – Where they Come Into Play

• Mechanical
• Electrical
• Plumbing
• Telecommunications
• Security
• Management
• Maintenance
Key Design Elements

- Redundancy (don’t be overly redundant)
- Technology Strategy
- Racks and Cabinets
- Cabling - note Cabling is NOT the enemy
- Room limitations/size
- Capacity (Electrical and Cooling)
- Pathways
- Suppression systems/Fire systems / Alarms
Pieces and Parts
ISO/IEC TIA Similar

Structured Cabling Hierarchy for Data Centers, continued

Figure 18.2 shows the CENELEC EN 50173-5 and ISO/IEC 24764 hierarchical structure.

Figure 18.2
Hierarchical structure of a data center from CENELEC EN 50173-5 and ISO/IEC 24764
Facilities
Networking
Procurement
Vendors
Security
CIO/CTO
Standards and Code Bodies

- ANSI/TIA/EIA: North American standards
- ISO/IEC: International standards
- IEEE: Electronics standards
- BICSI: Standards and best practices
- NEC: National Electrical Code
- NFPA: Fire Codes
Consortiums and .orgs

• BacNet.org
• ASHRAE
• Modbus.org
• ISOC, IAB, IESG, IETF, IRSG, IRTF
New Standards

- [https://beyondstandards.ieee.org](https://beyondstandards.ieee.org)
  - Full section on IoT
  - Connected vehicles
  - Industry publications
Why It’s Helpful

• Showcasing new standards applications in the marketplace
• Featuring new and emerging technologies
• Highlight innovative new areas of standards development
• Celebrate innovators and disruptors who collaborate to advance standards and technology
• Encourage participation in standards development
• Events and educational opportunities
<table>
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<th>Beyond Standards</th>
<th>Contributors</th>
<th>Contact Us</th>
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<td>Design Automation</td>
<td>Power and Energy</td>
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<td>Net Policy</td>
<td>Software Define Network</td>
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2018 ETHERNET ROADMAP
THE PAST, PRESENT, AND FUTURE OF ETHERNET

AUTOMOTIVE Ethernet is one of the Ethernet's major success stories. Forecasted to grow up to 500 million ports of Ethernet will ship in 10 million vehicles by 2018. Ethernet, due to its intrinsic scalability, will continue to grow as the cost and weight in vehicles provide economics of scale and interoperability. The bandwidth demand of connected cars could be the next big driver for Ethernet to go beyond 100GbE.

ENTERPRISE and Campus applications drive the bulk of Ethernet port shipments with hundreds of millions of ports shipping per year. Ethernet's roots are in internetwork area networks (LANs) where the entire Ethernet family, including the BASE-T products, can be found. LANs are rich in copper where over 70 billion meters of cable have been deployed over the past 35 years. Enterprise data centers are very cost sensitive and most servers deploy 1GbE and 10GbE.

CLOUD PROVIDERS were the first to adopt 100GbE, serving a large scale in 2018 for high-speed data centers. With a worldwide appetite for cloud computing, Cloud services have moved to 25GbE today and will move to 100GbE by the end of 2018. Unique networking architectures within these warehouse scale data centers have driven multiple multimode and single-mode fiber solutions at 100, 200, and 400GbE. The bandwidth demands of hyperscale data centers and service providers continue to grow exponentially and in a similar direction that blurs the lines between the two.

BUILDING AND INDUSTRIAL applications highlight the need for lower speed Ethernet solutions in harsh environments. The Ethernet community is working to define a single standard for 10 Mbit Operation Plus power delivery over a single twisted pair. This will consolidate a landscape of multiple legacy standards, driving the promise of Ethernet's multi-level interoperability to new heights for these spaces, as 2018 forecasts point to 18 million ports per year.

SERVICE PROVIDERS have delivered higher speed Ethernet solutions for decades. Router connections, client side optics for optical transport networks (OTN) equipment, and end-user backhaul have continually pushed Ethernet to higher rates and densities to meet the demands for wireless connectivity. And with global demand by consumers for video, this shows no signs of changing.

INTEROPERABILITY AND CERTIFICATION
The Ethernet Alliance is committed to breaking the barrier to leading industry consensus on Ethernet standards through its multi-vendor, interoperability demonstrations and workshops. The Ethernet Certification Program has taken the mission to the marketplace.

Our industry-driven, paid Certification Test Plan is based on the Ethernet standard, and products passing this test will be granted the Ethernet Alliance Certification badge. This logo will provide broad recognition for products that based on the IEEE 802.3 Ethernet standard, and provide confidence in the multi-vendor interoperability of those products. Vendors that achieve the Interop Certification will provide a single instance of the badge for all devices that ship with Ethernet capabilities.

The Interop Certification (ICP) is based on the I and II Test Procedure that was a part of the original Ethernet specification, while the Industry Certification (IC) includes the requirements for the IC, 802.3an, and the new validation. The logo will be a combination of the two.

2020+ 2018-2020 2020+

ETHERNET

https://www.ethernetalliance.org/interop/

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To get a PDF version of the roadmap and to find out more about the roadmap, please go to www.ethernetalliance.org/roadmap/
### PoE Types and Classes

<table>
<thead>
<tr>
<th>PoE Types and Classes</th>
<th>2-Pair PoE+ – Type 2</th>
<th>2-Pair PoE – Type 1</th>
<th>4-Pair PoE – Type 3</th>
<th>4-Pair PoE Type 4</th>
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<td>0 1 2 3 4</td>
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<td>40 51 62 71.3</td>
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</table>

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### Ethernet Speeds

**Link Speed (b/s)**

- **10M Ethernet**
- **100Mb/s Ethernet**
- **1G Ethernet**
- **10G Ethernet**
- **25GbE**
- **50GbE**
- **100GbE**
- **400GbE**
- **800GbE**
- **1.6TbE**

**Standard Completed**

- **1980**
- **1990**
- **2000**
- **2010**
- **2020**
- **2030**

- **Ethernet Speed**
- **Possible Future Speed**

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2018 BICSI Fall Conference & Exhibition
ETHERNET ECOSYSTEM

As streams turn into rivers and flow into the oceans, so does Ethernet - links flow from buildings (Ethernet links) and flow into the Internet. The Internet is formed at Internet Exchange Points (IXPs) that are遍布 around the world. The IXPs connect Telecommunications Companies, Cable companies, Cloud Providers, Content Delivery Networks, and user Ethernet in their data centers.

The Internet Exchange Point (IXPs) is where the Internet is made when major networks and companies connect using Ethernet. Conjunction facilities are usually near the IXPs so that they can avoid access or use. Internet exchanges are permanent locations.

Server Racks
Ethernet Switch and Router Racks
Patch Panels
Storage Racks
Transport Equipment
Value Networks
LIBS Racks
SIGNALLING METHODS

Most high speed Ethernet signaling has been Non Return to Zero (NRZ), but Pulse Amplitude Modulation 4 Level (PAM-4) signaling delivers twice as many bits per sample.

NRZ
Non-Return to Zero

PAM-4
Pulse Amplitude Modulation — 4 Levels

HOW TO GO FASTER

Higher signaling rates are achieved by using different modulation techniques to data rate. 25Gigabit sampling may create 25Gb/s NRZ, 50 Gb/s PAM-4 or 100Gb/s Coherent lanes.

After the data rate/lane is chosen, the number of lanes in a link determines the speed. This chart shows how 4, 8 or 16 lanes can be used to generate 400GbE links.
**Form Factors**

This diagram shows the most common form factors used in Ethernet ports. Hundreds of millions of RJ45 ports are sold a year while tens of millions of SFP and millions of QSFP ports ship a year.

1–4 Lane Interfaces

This diagram shows new form factors initially designed for 100GbE and 400GbE Ethernet ports. All have 4 or 8 lanes and the OBO has up to 16 lanes. The power consumption of the modules is proportional to the surface area of the module.

4-16 Lane Interfaces
FORM FACTORS

1-4 Lane Interfaces

- Twisted Pair Cat "X"
- Twinax
- Duplex and Parallel Optical Fiber

4-16 Lane Interfaces

- On Board Optics (OBO)
- ASIC

*Square inches of top surface of the module
<table>
<thead>
<tr>
<th>EMERGING INTERFACES AND NOMENCLATURE</th>
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<td><strong>Electrical Interface</strong></td>
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<td>10BASE-</td>
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<tr>
<td>100BASE-</td>
</tr>
<tr>
<td>1000BASE-</td>
</tr>
<tr>
<td>2.5GBASE-</td>
</tr>
<tr>
<td>5GBASE-</td>
</tr>
<tr>
<td>10GBASE-</td>
</tr>
<tr>
<td>40GBASE-</td>
</tr>
<tr>
<td>100GBASE-</td>
</tr>
<tr>
<td>400GBASE-</td>
</tr>
</tbody>
</table>

- Gray Text = IEEE Standard
- Red Text = In Standardization
- Green Text = In Study Group
- Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces
Uplinks

<table>
<thead>
<tr>
<th>Type</th>
<th>Fiber Type</th>
<th>Power Consumption Max W</th>
</tr>
</thead>
<tbody>
<tr>
<td>10GBASE-SR</td>
<td>MMF</td>
<td>1</td>
</tr>
<tr>
<td>10GBASE-LR</td>
<td>SMF</td>
<td>1 - 1.5</td>
</tr>
<tr>
<td>40GBASE-SR4</td>
<td>MMF</td>
<td>1.2 - 1.5</td>
</tr>
<tr>
<td>40GBASE-LR4</td>
<td>SMF</td>
<td>3.5</td>
</tr>
<tr>
<td>100GBASE-SR10</td>
<td>MMF</td>
<td>3.5 - 4</td>
</tr>
<tr>
<td>100GBASE-LR4</td>
<td>SMF</td>
<td>3.5 - 5</td>
</tr>
</tbody>
</table>

Power is only part of the equation
Unused ports draw power
Central power supplies can be more efficient even though they draw more power
## IEEE Single Mode Projects

<table>
<thead>
<tr>
<th>Data Rate</th>
<th>Project</th>
<th>Type of Module</th>
<th>Nomenclatures</th>
<th>Reach (km)</th>
<th>Ratified</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>802.3ae</td>
<td>SFP+</td>
<td>10GBASE-LR, ER</td>
<td>10,40</td>
<td>2002</td>
</tr>
<tr>
<td>25</td>
<td>802.3cc</td>
<td>SFP28</td>
<td>25GBASE-LR, ER</td>
<td>10,30</td>
<td>2017</td>
</tr>
<tr>
<td>40</td>
<td>802.3ba, bm</td>
<td>QSFP+</td>
<td>40GBASE-LR, ER</td>
<td>10,40</td>
<td>2010, 2015</td>
</tr>
<tr>
<td>50</td>
<td>802.3cd</td>
<td>SFP56</td>
<td>50GBASE-FR, LR</td>
<td>2, 10</td>
<td>2018</td>
</tr>
<tr>
<td>100</td>
<td>802.3ba</td>
<td>QSFP28</td>
<td>100GBASE-DR</td>
<td>.5</td>
<td>2010</td>
</tr>
<tr>
<td>100</td>
<td>802.3cd</td>
<td>QSFP28</td>
<td>100GBASE-LR4, ER4</td>
<td>10,40</td>
<td>2018</td>
</tr>
<tr>
<td>200</td>
<td>802.3bs</td>
<td>QSFP56</td>
<td>200GBASE-DR4</td>
<td>.5</td>
<td>2017</td>
</tr>
<tr>
<td>200</td>
<td>802.3bs</td>
<td>QSFP56</td>
<td>200GBASE-FR4, LR4</td>
<td>2, 10</td>
<td>2017</td>
</tr>
<tr>
<td>400</td>
<td>802.3bs</td>
<td>TBD</td>
<td>400GBASE-DR4</td>
<td>.5</td>
<td>2017</td>
</tr>
<tr>
<td>400</td>
<td>802.3bs</td>
<td>CFP8</td>
<td>400GBASE-FR8, LR8</td>
<td>2, 10</td>
<td>2017</td>
</tr>
<tr>
<td>800</td>
<td>?</td>
<td>?</td>
<td>800GBASE-FR8, LR8</td>
<td>TBD</td>
<td>~2021</td>
</tr>
</tbody>
</table>
What is QSFP56?

• **Overview**
  • 200Gbps hot pluggable transceiver in a compact QSFP56 form factor
  • Optical connectivity based on two Singlemode Fiber (SMF) LC connectors
  • Optical engine combining uncooled 4 X 50 Gbps CWDM DFB lasers with integrated MUX/DeMUX
  • The optical signals are modulated using a 4-level pulse amplitude modulation (PAM4) format
  • Optical Reach: up to 2km
  • Built in digital diagnostics – Transmitter Power Monitoring (TPM) and Receive Signal Strength Indicator (RSSI)
  • RoHS-6 compliant
  • Operating case temperature range of 0 to 70°C
  • Based on IEEE P802.3bs standard for 200G FR4 and on QSFP656 baseline specification
Fibre Channel Over Ethernet  FCoE

- Allows all Ethernet traffic in the data center
- Encapsulates Fibre Channel information over Ethernet (802.3)
## Fibre Channel Roadmap

### Fibre Channel Speed Roadmap — Inter-Switch Link

<table>
<thead>
<tr>
<th>Product Naming</th>
<th>Throughput (MBps)</th>
<th>Equivalent Line Rate (Gbaud)†</th>
<th>T11 Spec Technically Completed (Years)‡</th>
<th>Market Availability (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10GFC</td>
<td>2400</td>
<td>10.52</td>
<td>2003</td>
<td>2009</td>
</tr>
<tr>
<td>20GFC</td>
<td>4800</td>
<td>21.04</td>
<td>Not Applicable</td>
<td>2008</td>
</tr>
<tr>
<td>40GFCoE</td>
<td>9600</td>
<td>41.25</td>
<td>2010</td>
<td>2013</td>
</tr>
<tr>
<td>100GFCoE</td>
<td>24000</td>
<td>10X10.3125</td>
<td>2010</td>
<td>Market Demand</td>
</tr>
<tr>
<td>100GFCoE</td>
<td>24000</td>
<td>4X25.78125</td>
<td>2015</td>
<td>Market Demand</td>
</tr>
<tr>
<td>128GFCp</td>
<td>25600</td>
<td>4X28.05</td>
<td>2014</td>
<td>2016</td>
</tr>
<tr>
<td>256GFCp</td>
<td>51200</td>
<td>4X57.8</td>
<td>2017</td>
<td>2019</td>
</tr>
<tr>
<td>400GFCoE</td>
<td>96000</td>
<td>8X51.5625</td>
<td>2017</td>
<td>Market Demand</td>
</tr>
<tr>
<td>1TFCoE</td>
<td>240000</td>
<td>TBD</td>
<td>TBD</td>
<td>Market Demand</td>
</tr>
</tbody>
</table>
100GbE QSFP28 Consumption in 2016

- Units shipped
- SR4 modules had the greatest contribution to 2016 shipments of QSFP28 modules

Chart courtesy of Dale Murray, LightCounting
Singlemode versus Multimode versus Copper

• Total channel cost Day One
  • Switch Cost, Server NIC cost, uplink port cost, fiber
• Total costs day two
  • Power, Cooling, maintenance
  • This does not always take a front seat, but should
FORM FACTORS

This diagram shows the most common form factors used in Ethernet ports. Hundreds of millions of RJ45 ports are sold a year while tens of millions of SFP and millions of QSFP ports ship a year.

1–4 Lane Interfaces

4-16 Lane Interfaces

This diagram shows new form factors initially designed for 100GbE and 400GbE Ethernet ports. All have 4 or 8 lanes and the OBO has up to 16 lanes. The power consumption of the modules is proportional to the surface area of the module.
3 Main Types of DC High-Speed Interconnects

**Direct Attach Copper (DAC)**
- Copper Wires
- Key feature = Lowest Priced Link
- 25/50/100Gbe: 3m-5m reach

**Active Optical Cables**
- 2 Transceivers w/optical fiber bonded inside
- Key feature = Lowest Priced Optical Link
- 100m/200m Reaches

**Optical Transceivers**
- Converts electrical signals to optical laser light sent over optical fibers
- Key features = Connectors & Long Reaches
- "Transceiver"
- 4-channels Transmitter
- 4-channels Receiver

Copper Cables

Transceivers with Integrated Fibers

Transceivers with Detachable MPO or LC Connectors
DAC in the Rack

3-5m at 25/50/100G
7m at 10/40G
Figure 2: Structured Cabling vs. ToR Topology. ToR eliminates central patching in the distribution area.
Note: Designs based on a three-tier switch architecture.
<table>
<thead>
<tr>
<th>Equipment and Unit Price</th>
<th>ToR</th>
<th>Structured Cabling</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Price</td>
<td>Units</td>
</tr>
<tr>
<td>32-port 10G ToR Switches ($15,000)</td>
<td>78</td>
<td>$1,170,000</td>
<td>35</td>
</tr>
<tr>
<td>Redundant Power Supplies ($500)</td>
<td>78</td>
<td>$39,000</td>
<td>35</td>
</tr>
<tr>
<td>SFP+ Uplink Ports ($1500)</td>
<td>312</td>
<td>$468,000</td>
<td>140</td>
</tr>
<tr>
<td>32-Port Aggregation Switches ($25,000)</td>
<td>10</td>
<td>$250,000</td>
<td>5</td>
</tr>
<tr>
<td>SFP+ Modules ($5000)</td>
<td>80</td>
<td>$400,000</td>
<td>40</td>
</tr>
<tr>
<td>Redundant Power Supplies ($500)</td>
<td>10</td>
<td>$5,000</td>
<td>5</td>
</tr>
<tr>
<td>Core Switches ($80,000)</td>
<td>2</td>
<td>$160,000</td>
<td>2</td>
</tr>
<tr>
<td>Redundant Power Supplies at ($7,500)</td>
<td>2</td>
<td>$15,000</td>
<td>2</td>
</tr>
<tr>
<td>Fiber Cards for Uplinks at ($70,000)</td>
<td>4</td>
<td>$280,000</td>
<td>2</td>
</tr>
<tr>
<td><strong>Cabling Total</strong></td>
<td><strong>$240,000</strong></td>
<td></td>
<td><strong>$110,000</strong></td>
</tr>
<tr>
<td><strong>Equipment Total (not including software)</strong></td>
<td><strong>$2,787,000</strong></td>
<td></td>
<td><strong>$1,395,000</strong></td>
</tr>
<tr>
<td>3 Years Maintenance</td>
<td><strong>$1,200,000</strong></td>
<td></td>
<td><strong>$570,000</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$4,227,000</strong></td>
<td></td>
<td><strong>$2,075,000</strong></td>
</tr>
</tbody>
</table>

*Figure 3: ToR vs. Structured Cabling Cost Comparison (based on MSRP at time of print) for an actual 39-cabinet data center (assumes average 5 to 6kW per cabinet, dual network, redundant power supplies, 14 servers per cabinet, four uplinks per switch, 2.5-meter SFP+ direct attach cable assemblies for each used ToR port, and category 6A UTP for structured cabling).*
## From CCCA

<table>
<thead>
<tr>
<th>Equipment</th>
<th>ToR</th>
<th>Structured Cabling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Total</td>
</tr>
<tr>
<td>32-port 10G ToR Switches</td>
<td>78</td>
<td>2496</td>
</tr>
<tr>
<td>32-Port Aggregation Switches</td>
<td>10</td>
<td>320</td>
</tr>
<tr>
<td>Fiber Cards for Core Uplinks</td>
<td>4</td>
<td>128</td>
</tr>
<tr>
<td><strong>TOTAL PORT USAGE</strong></td>
<td><strong>2944</strong></td>
<td><strong>1444</strong></td>
</tr>
</tbody>
</table>

*Figure 4: Switch port utilization for ToR vs. Structured Cabling for an actual 39-cabinet data center (assumes average 5 to 6kW per cabinet, dual network, redundant power supplies, 14 servers per cabinet and four uplinks per switch).*
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Leaf/Spine DAC</th>
<th>Leaf/Spine 10GBASE-T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low density 14 Servers/Cab</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Equip/Cabling Cost</td>
<td>$11,944,235.65</td>
<td>$8,638,321.02</td>
</tr>
<tr>
<td>Average Cost/Server Cab</td>
<td>$71,096.64</td>
<td>$59,988.34</td>
</tr>
<tr>
<td>Annual Power cost Networking</td>
<td>$101,419.78</td>
<td>$57,017.09</td>
</tr>
<tr>
<td>Total Cabling Cost</td>
<td>$481,250.59</td>
<td>$70,327.30</td>
</tr>
<tr>
<td><strong>High Density 40 Servers/Cab</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Equip/Cabling Cost</td>
<td>$26,394,022.02</td>
<td>$21,596,114.19</td>
</tr>
<tr>
<td>Average Cost/Server Cab</td>
<td>$157,107.27</td>
<td>$149,973.02</td>
</tr>
<tr>
<td>Annual Power cost Networking</td>
<td>$177,610.75</td>
<td>$106,717.82</td>
</tr>
<tr>
<td>Total Cabling Cost</td>
<td>$5,123,942.02</td>
<td>$2,078,260.76</td>
</tr>
</tbody>
</table>
The Beginning of ToR Architectures
Longevity

- OS1 (OS2 over 2km) FDDI, OM1, OM2, OM3, OM4, OM5
- Category 6A 3, 4, 5, 5E, 6, 6A
Point to Point

• Single use
• Non-negotiating
• Sometimes closed (proprietary)
• Now running 30-50% of Capital $

• High ticket item for Electronics manufacturers
• Often purchased by the networking team
Points to Remember – Number of Servers Restricted by....

- Power is your limiting factor for # of servers per cabinet
- Cooling capacity
- Weight
- Height of Cabinet

- Budget

Integrated Building Solutions

Open protocol framework
- Highly scalable – small to large network of buildings

Integration to the following protocols:

Modbus  LONWORKS  BACnet®
NEC 240-3

- Continuous loads
- Conductor ampacity
- Terminal temperature ratings
- System voltage
- Conductor insulation
- Special application

- Power Loss Hazard
- Fire Alarm System Circuit Conductors
- Devices Rated 800 Amperes or Less
- Remote-Control, Signaling, and Power-Limited Circuit Conductors
- Tap Conductors
- Transformer Secondary Conductors
- Motor-Operated Appliance Circuit Conductors
- Air-Conditioning and Refrigeration Equipment Circuit Conductors
- Motor and Motor-Control Circuit Conductors
- Phase Converter Supply Conductors
- Capacitor Circuit Conductors
- Electric Welder Circuit Conductors
How Far Can it Go?

• 44000/500 = 88
• Distances shown versus category cable- 8 stands (4 pair) ≤100m
• Category cable limited to 100m for Ethernet

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Device VA</th>
<th>Maximum Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 AWG</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>500</td>
</tr>
<tr>
<td>18 AWG</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1000</td>
</tr>
</tbody>
</table>
Door Controls

- Door Chord Connects Push Rail to Controller
- Door With Magnetic Lock
  - Electrically Operated Push to Open Rail
- Door With Electric Strike
  - Optional Interior Push To Open Button
  - Exterior Access Station
- Controller
  - Power Supply With Battery Backup
  - To 110 VAC
Are all Cables the Same?

- Electrically different
- Conductor size depends on power and signal
- Composite cables lower labor
- Will talk to different systems
- Category 5E or 6 cables can NOT run everything in an intelligent building
- 4 Category cables = 4 sets of twisted pairs
- Not all conductors are the correct size
- Waste of unneeded pairs/conductors
- 32 conductors when 16 are required
- Will still need control cables for electrical reasons
Thermostat

• 16 or 18 AWG 4/5 strand wire to thermostat
• 1 Thermostat / 5 offices = ~1/500sq’
<table>
<thead>
<tr>
<th>TIA TR-42 Recommendation</th>
<th>ISO/IEC Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature Rise</strong></td>
<td><strong>Max Current per twisted Pair</strong></td>
</tr>
<tr>
<td>5</td>
<td>420mA</td>
</tr>
<tr>
<td>7.5</td>
<td>520mA</td>
</tr>
<tr>
<td>10</td>
<td>600mA</td>
</tr>
<tr>
<td>12.5</td>
<td>670mA</td>
</tr>
<tr>
<td>15</td>
<td>720mA</td>
</tr>
</tbody>
</table>

With maximum 51W UPOE capacity, temperature for 100-cable bundle increased 10 degrees. This is as required by PoE Plus cable standard request defined in 802.3at.
Cable Considerations

• Don’t run more than you need if there is not a real possibility that you will use it.
  • Don’t run 4 pair cables if two will due long term
  • Know your distances
  • Sometimes it pays to operate outside of the standards
CCTV Change to IP

- RG cables go approximately 750’
- Traditional category cables go 100m (328’)
- Video Optimized cable 850’ with PoE+

<table>
<thead>
<tr>
<th>VIDEO OPTIMIZED CABLE 850’</th>
</tr>
</thead>
<tbody>
<tr>
<td>750’</td>
</tr>
<tr>
<td>328’</td>
</tr>
</tbody>
</table>

MUST ADD IDF AND/OR REPEATER
## Cost with Transceivers

<table>
<thead>
<tr>
<th>Materials from 328' to 750'</th>
<th>Each</th>
<th>Extended</th>
<th>Additional Cost per Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Cost of Transceiver</td>
<td>$800.00</td>
<td>$1,600.00</td>
<td></td>
</tr>
<tr>
<td>2 Cost to Add Power</td>
<td>$250.00</td>
<td>$500.00</td>
<td></td>
</tr>
<tr>
<td>422 Additional Fiber, connectors, etc.</td>
<td>$506.40</td>
<td>$2,606.40</td>
<td>$2,006.40</td>
</tr>
<tr>
<td>3 Additional IDFs</td>
<td>$1,500.00</td>
<td>$4,500.00</td>
<td>$3,900.00</td>
</tr>
<tr>
<td>3 Power, Switch, Enclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000' Cable Option</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- GameChanger Cable Optimized for Video 850’ no repeater
Doors Only
Composite Cable Example

ACCESS CONTROL
ALL-IN-ONE / COMPOSITE CABLE
6 CONDUCTOR 18 AWG SHIELDED – Reader
4 CONDUCTOR 18 AWG SHIELDED – Rex/Motion
2 CONDUCTOR 16 AWG SHIELDED – Lock Power
4 CONDUCTOR 22 AWG SHIELDED – Door Contact
Not all Composites are the Same

• You must verify all components
• Look at shielding of all components
  • Unshielded cables next to magnetic doors
  • Unshielded cables next to noise sources
  • Not all of these cables are balanced
  • Not all pairs are twisted
NEC Sections

• Article 725 – Remote Control, Signaling Circuits
• Article 770 Optical Fiber Cables and Raceways
• Article 800 Communications Circuits
• Article 820 Community Antenna Television (CATV)
Coatings and Jackets

• Not limited to plenum and riser

• Ceramic Reactive Coatings for Fire
  • Circuit Integrity Cable
  • Turns to ceramic when exposed to Fire/Water
  • Maintains integrity of circuit for 2 hours
    • Higher hour ratings require conduit encasement
New Circuit Integrity Requirements

• 72.F requirements section 3.3.188 which states “the ability of a conductor, optic fiber, radio carrier, or other means for transmitting system information to remain operational during fire conditions. The required functionality is tested and verified by UL 2196 and is one of the most stringent tests conducted to verify operation during fire events
Shielded and Not Shielded Applications

• Composite Cables may or may not have the right combination
• Vary within states/countries due to governance
• Not having a shield for some applications is a big thing
Why you Don’t Need Category Everywhere

• Wasted pairs
• Electrically insufficient
• Code insufficient
• Application insufficient
Do We Need IP Everywhere?

• Many kinds of data and protocols
• Not all are IP
• Not all are needed
Miscellaneous Protocols

• Consider a gateway
• Consider if solution sets will do
• Consider whether real-time communications between systems is needed
• Reach out to your vendor/integrators and ask about solutions
• Do your own research!
• Beware over planning for information that will not hit your data center
A Word About the Information

• Not all information is useful
• The more you store the more you have to process
• Some information will be M2M only
• The more you capture, the more you will want to capture
• Give info a litmus test
  • Is it useful?
  • Is it actionable?
  • Can it be measured?
  • Can changes be measured?
  • Is it in your disaster recovery/business continuity plan?
Build a Chart – Expect it to Change

• What information will be gathered by each system
• Where will that information be stored?
  • Locally
  • Centrally
  • Cloud
• How long will it need to be stored?
• Will the information need to be backed up?
• What other systems will interface with each system?
• Will the interfaces require full information or partial information?
Information You Don’t Need...

- Personal device information
- Active Noise (calls, etc.)
- Passive noise (M2M)
- Nearfield Communications (maybe)
What is Near-field Communication?

- Generally mobile device to fixed device
- Generally quick bursts of data
- Normally command based
Near Field Hybrid Example

- Apple Pay
- Phone communicates to reader (Near Field)
- Reader processes payment (Network Communication)
Data Center Considerations

• Segmentation of networks
• Amount of storage
• Location of data
  • Cloud?
  • Colo?
  • In house?
Considerations for Location of Data

- Latency
- Availability
- Interfaces with other data/systems
- Longevity
- Privacy
- Personally identifiable information
How Many Data Centers

• Edge
• Centralized
• Warm/Hot site
• Some combination
• Data Centers in 2018 will be different!
Little Known Nuggets of Info

- Rebates and Relationships Exist
  - Who benefits?
  - Does it sway product recommendations?
  - How do you check them?
  - What value comes as a result of markup?

- What are other sources of information?
  - Power companies can be a great source and also can provide grants
  - Trade Associations
  - A&E’s, Consultants
Understanding your Supply Chain

- No one works for free
- No one stocks everything
- You can benefit from flexibility
- Price several options
- Understand how the standards can work for you
- Know the difference between a code and a standard
- Know what you need ahead of time. If you are constantly reacting you are not part of the process and doomed to fail
- Know other solutions; there is NO one size fits all
Myth Busters (shameless rip off) 101

• If communications are IP then you must use 4 pairs of category cable
• You must re-cable your building
• You need new systems for IoT
• You need to quintuple (at least) capacity for everything
• IoT is going to break the bank
• Plan for the worst, expect the best
If communications are IP then you must use 4 pairs of category cable

You can not have your fire system talk to other systems

The amount of traffic will kill my network

All communications are IP
   M2M
   Near field protocols

All of the IoT traffic will traverse my main network

My Vendor is the best source of information
Understand the Where, What and How of Communications

• Gateway – leaves end systems intact
  • Think translator
• Native – systems share a network (generally IP)
• Wireless is part of the equation
• Switches will determine which network
• The most secure network is one no one can get to from the outside
Make a Roadmap of Your Own

• The right vendor questionnaire
  • Ask about interoperability
  • Ask about resources available to you
  • Will the vendor support directly or will they rely on integrators/installers
  • Ask about knowledge transfer
  • Ask for direct pricing
  • Don’t forget forward looking questions
New Code Changes for PoE/PoE+

- LP Cables are an OPTION
- Ampacity – governs 725.144
  - New in 2017
  - Max current a conductor can carry continuously without exceeding temperature rating
- 802.3bt
  - Type 3 60W PSE, 51W PD
  - Type 4 90W PSE, 71.3W PD
  - Classes 1-4 (previous generation)
  - Classes 5, 6 (Type 3)
  - Classes 7, 8 (Type 4)
Typical Uniform Coverage Area Grid Pattern

$L_{\text{max}} = R = 13 \text{ m (42 ft)}$

$X = 18.3 \text{ m (60 ft)}$
Conclusions

• Determine what devices will be on or near your networks
• Plan for the bandwidth within reason
• Plan for changes – status as usual won’t work
• Don’t plan in a vacuum
• Be prepared to reevaluate often
QUESTIONS?
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