ORE WIRELESS:
FOUR STEPS
to Successful Deployment
Presenter Bio

- Yuna Shin
- Senior Product Manager, Copper Leviton Network Solutions
- Bothell, WA U.S.A.
- Manages Leviton's extensive selection of Category 6A, 6, and 5e patch panels and connectors
By the end of this webinar, you will be able to

- Understand what determines wireless speed
- Plan properly for wireless deployment
- Make the right product choices
- Understand 2.5GBASE-T and 5GBASE-T
Four Steps to Successful Wireless Deployment

**STEP 1**
Understand Wireless Technology

**STEP 2**
Understand Applications and Capacity

**STEP 3**
Understand Environments and Architecture

**STEP 4**
Make Cabling and Connectivity Choices

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September 24-28 | Las Vegas, NV
Evolution of 802.11

1997
802.11 • 2 Mb/s
802.11b • 11 Mb/s
802.11a • 54 Mb/s

1999

2003
802.11g • 54 Mb/s

2009
802.11n • 600 Mb/s

2013/2015
802.11ac Wave 1 • 1.3 Gb/s
802.11ac Wave 2 • 6.93 Gb/s

Est. 2018
802.11ax • 10 Gb/s

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Market Driver: Bandwidth Explosion from Digital Transformation

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Impact</th>
</tr>
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<tbody>
<tr>
<td>Office Buildings</td>
<td>50% Wireless</td>
</tr>
<tr>
<td>BYOD and Video Conferencing</td>
<td>IP traffic will pass two (2) Zettabytes annually by 2019</td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Smart Machines</td>
<td></td>
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<tr>
<td>Education</td>
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<td>Digital Learning and Security</td>
<td></td>
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<tr>
<td>Health Care</td>
<td></td>
</tr>
<tr>
<td>Medical Devices</td>
<td></td>
</tr>
</tbody>
</table>

Exabytes

Workplace Efficiency

- **802.11g**: 54 Mb/s, 13 min. 54 sec.
- **802.11n**: 600 Mb/s, 1 min. 15 sec.
- **802.11ac**: 1.3 Gb/s, 33 sec.
- **802.11ac**: 6.93 Gb/s, 6 sec.
## Wireless Standards at a Glance

<table>
<thead>
<tr>
<th></th>
<th>802.11a</th>
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<tr>
<td><strong>Spatial Streams</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
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<td>8</td>
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</tr>
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<td><strong>Maximum Throughput</strong></td>
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**INCREASING SPEED AND POWER**

### 2017 BICSI Fall Conference & Exhibition
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# Wireless Standards at a Glance

## Increasing Speed and Power

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**INCREASING SPEED AND POWER**

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**September 24-28** | **Las Vegas, NV**
# Wireless Standards at a Glance

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**Increasing Speed and Power**

- **802.11a**: 54 Mb/s
- **802.11b**: 11 Mb/s
- **802.11g**: 54 Mb/s
- **802.11n**: 600 Mb/s
- **802.11ac Wave 1**: 1.3 Gb/s
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INCREASING SPEED AND POWER

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What Determines Wireless Speed?

**Channel Bandwidth**
- Capacity
- 2.4 GhZ
- 5 GhZ
- 20 MHZ (802.11g)
- 40 MHZ (802.11n)
- 80 MHZ (802.11ac)
- 160 MHZ

**Antenna and Spatial Streams**
- Concentrated signal through multiple paths
- SISO
- MIMO

**Modulation**
- Speed
- 16 QAM 4 bits per modulation symbol
- 64 QAM 6 bits per modulation symbol
- 256 QAM 8 bits per modulation symbol

**Capacity**
- Concentrated signal through multiple paths

**Speed**
- 33% speed increase

**2.4 GhZ**
- 20 MHZ (802.11g)
- 40 MHZ (802.11n)
- 80 MHZ (802.11ac)
- 160 MHZ

**5 GhZ**
- 20 MHZ (802.11g)
- 40 MHZ (802.11n)
- 80 MHZ (802.11ac)
- 160 MHZ

**Modulation**
- 16 QAM 4 bits per modulation symbol
- 64 QAM 6 bits per modulation symbol
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## Channel Bandwidth

Wider Bandwidth – More Capacity

<table>
<thead>
<tr>
<th>Channel Bandwidth (MHz)</th>
<th>802.11g</th>
<th>802.11n</th>
<th>802.11ac</th>
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<tbody>
<tr>
<td></td>
<td>20</td>
<td>20, 40</td>
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</table>

- **20MHz**
- **40MHz**
- **80MHz**
- **160MHz**
Antenna and Spatial Streams
Concentrated signal through multiple paths

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<td></td>
<td></td>
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Beamforming
Modulation
Higher order modulation – Faster Speed

<table>
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<th>802.11ac</th>
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<tr>
<td></td>
<td>Wave 1</td>
<td>Wave 2</td>
<td>Wave 1</td>
</tr>
<tr>
<td>256 QAM</td>
<td>64</td>
<td>256</td>
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<tr>
<td>64 QAM</td>
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<tr>
<td>BPSK</td>
<td></td>
<td></td>
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</tr>
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</table>

256 QAM
8 bits per symbol

64 QAM
6 bits per symbol

33% Speed Increase
Benefits of 802.11ac

- Does 802.11ac WAP provide more capacity? **YES**
- Does 802.11ac WAP provide faster speed? **YES**
- Does 802.11ac WAP provide cleaner signal? **YES**
- Does 802.11ac WAP provide wider range? **NO**
Understanding Tradeoff

Coverage

More susceptible to obstruction

- 5Ghz
- 2.4Ghz

Need to be closer

- 256 QAM (8 bits per symbol)
- 64 QAM (6 bits per symbol)

Planning is critical

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Wireless Access Point Transition

Enterprise AP Volume Split

Source: Dell'Oro Group Wireless LAN 5-year Forecast Jan 2015

Enterprise 802.11ac AP Transition

Source: Dell'Oro Group Wireless LAN 5-year Forecast Jan 2016
Applications and Capacity
Application Type & Number of People and Devices

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Enterprise Building
Capacity

Commercial
Open spaces
Offices
Conference Rooms

Education
Lecture Halls
Classrooms
Dormitories
Libraries
Open Spaces

Health Care
Waiting Rooms
Reception Areas
Doctors Offices
Surgery Rooms
Imaging Rooms

Manufacturing
Factory Floors
Warehouses
Offices
Enterprise Building
Applications

**Commercial**
- Laptops
- Computers
- Video Conferencing
- VoIP
- Smart phones
- Tablets

**Education**
- Laptops
- Computers
- Tablets
- Smart phones
- Lecture

**Health Care**
- Computers
- Smart phone
- Laptops
- Imaging Devices
- Tablets
- RTLS

**Manufacturing**
- Inventory Control
- Line automation
- Smart Machines

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Environments and Architecture
Environments and Architecture

- Floor layout
  - Open, closed, semi closed

- Size
  - Small, medium, large

- Building materials

- Building furnishing

- 802.11ac – RF Barriers at 5GHz
  - Concrete, security glass, metal partitions
WAP Installation Consideration

Drop Ceiling

Wall

Enclosures

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Design Recommendations
ISO/IEC TR-24704

- Array of tight-fitting hexagonal cells
- 12-meter radius limit
- Outlet at center of the cell
Design Recommendations
TIA TSB-162-A

802.11ac Cabling Structure
Based on a 60 sq. ft. Uniform Cell Size

- **WAP Cord:** Max = 13m (42ft)
- **6A Cable:** Max = 80m (262ft)
- **Equip. Cord:** Max = 6m (20ft)
Design Example
TIA TSB-162-A

802.11ac Cabling Structure
Based on a 60 sq. ft. Uniform Cell Size
Design Recommendations
TIA-4966

- Occupancy recommendation
- One access point per 230 square meters
- Noisy environments with high RF interference concentration
  - One access point per 150 square meter
Wireless Speed

1997
802.11 > 2 Mb/s

1999
802.11b > 11 Mb/s
802.11a > 54 Mb/s

2003
802.11g > 54 Mb/s

2009
802.11n > 500 Mb/s

2013 / 2015
802.11ac Wave 1 > 1.3 Gb/s
802.11ac Wave 2 > 6.93 Gb/s

Est. 2018
802.11ax > 10 Gb/s
## Category Cabling Supporting Wireless Speed

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<td>6A</td>
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<td><strong>Maximum Bandwidth</strong></td>
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<td>250 MHz</td>
<td>500 MHz</td>
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<tr>
<td><strong>Maximum Data Rate</strong></td>
<td>1000BASE-T</td>
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<td>10GBASE-T</td>
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<td>1999</td>
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### Wireless Standards

- **802.11g**
  - Maximum Data Rate: > 54 Mb/s

- **802.11n**
  - Maximum Data Rate: > 600 Mb/s

- **802.11ac**
  - Wave 1: > 1.3 Gb/s
  - Wave 2: > 6.93 Gb/s

- **802.11ax**
  - Maximum Data Rate: > 10 Gb/s
Only Cat 6A Supports 802.11ac or Higher

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<td>Unshielded/Shielded</td>
<td>Unshielded/Shielded</td>
<td>Unshielded/Shielded</td>
</tr>
<tr>
<td>Date Created</td>
<td>1999</td>
<td>1999</td>
<td>2006</td>
<td>2006</td>
</tr>
</tbody>
</table>

- **802.11g**: > 54 Mb/s
- **802.11n**: > 600 Mb/s
- **802.11ac**: Wave 1 > 1.3 Gb/s, Wave 2 > 6.93 Gb/s
- **802.11ax**: > 10 Gb/s
Cabling and Connectivity
TIA TSB-162-A Recommendation

- Two Cat 6A cables per AP
  - Higher data rates
  - Increased power delivery
- Four Cat 6A drops to every AP for future needs
- Plenum rated equipment outlets and patch cords
Cabling and Connectivity Choices
Quality, Reliability, and Performance

Cables + Connectors + Cords

- Third Party Tested
- Plenum Rated
- Support PoE and PoE+
  - 802.11n: PoE (15W)
  - 802.11ac: PoE+ (30W)
2.5/5GBASE-T
Getting more with existing Cat 5e and Cat 6 infrastructure?

- **2.5GBASE-T**
  - Category 5e/6
  - 200 MHz
  - 2.5 Gb/s

- **5GBASE-T**
  - Category 5e/6
  - 200 MHz
  - 5 Gb/s

**1000BASE-T**
- 2.5 Gb/s

**10GBASE-T**
- 5 Gb/s

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Currently Installed Cat 5e and Cat 6 Components

More than 70 Billion meters of Cat 5e and Cat 6 cabling were sold and More than 1.3 Billion Cat 5e and Cat 6 ports are installed last 12 years
Infrastructure for 1G Wireless Network
Category 5e and 6 Cabling

Switch
1000BASE-T
Supports wired and wireless networks up to 1 Gb/s

Cable
Cat 5e
Cat 6
Supports wired and wireless networks up to 1 Gb/s

WAP
802.11n
802.11ac (Wave 1)
Supports wireless networks up to 1 Gb/s

Wireless speed
< 1 Gb/s
Infrastructure for 1G Wireless Network

Category 6A Cabling

Switch
- 10GBASE-T
  - Supports wired and wireless networks up to 10 Gb/s

Cable
- Cat 6A
  - Supports wired and wireless networks up to 10 Gb/s

WAP
- 802.11ac (Wave 2)
  - Supports wireless networks up to 6.93 Gb/s
  - Wireless speed > 1 Gb/s

Wireless speed

Supports wired and wireless networks up to 10 Gb/s

Supports wireless networks up to 6.93 Gb/s

Supports wireless networks up to 6.93 Gb/s

Supports wireless networks up to 6.93 Gb/s

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Upgrading to Cat 6A is Expensive

Switch: 10GBASE-T
- Supports wired and wireless networks up to 10 Gb/s

Cat 6A: Supports wired and wireless networks up to 10 Gb/s

WAP: 802.11ac (Wave 2)
- Supports wireless networks up to 6.93 Gb/s

Wireless speed: > 1 Gb/s
What is 2.5GBASE-T and 5GBASE-T?

Temporary Alternative to Upgrading Infrastructure

Switch
10GBASE-T
Supports wired and wireless networks of 1, 2.5, 5 Gb/s

Cable
Cat 6A
Existing wired links for improved wireless speed up to 5 Gb/s

WAP
802.11ac (Wave 2)
Supports wireless networks up to 5 Gb/s

Wireless speed
Up to 5 Gb/s
IEEE 802.3bz and TIA TSB-5021

- **February 2014**: IEEE call for interest (CFI) occurred
- **May 2015**: IEEE 802.3bz technical baseline adopted
- **June 2015**: IEEE 802.3bz Task Forces review begins
- **July 2015**: IEEE 802.3bz sponsor ballot will be opened
- **May 2016**: IEEE 802.3bz sponsored ballot will be closed
- **April 2016**: IEEE 802.3bz technical baseline adopted
- **January 2016**: IEEE 802.3 working group ballot initiated
- **May 2016**: IEEE 802.3bz ratified
- **September 2016**: IEEE 802.3bz ratified
- **February 2017**: TIA TSB-5021 published

Source: NBASE-T Alliance, Cisco

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### 3 Things You Need to Know About 2.5GBASE-T and 5GBASE-T

<table>
<thead>
<tr>
<th>Speed</th>
<th>Category</th>
<th>Bandwidth</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5GBASE-T</td>
<td>Category 5e/6</td>
<td>100 MHz</td>
<td>2.5 Gb/s</td>
</tr>
<tr>
<td>5GBASE-T</td>
<td>Category 5e/6</td>
<td>200 MHz</td>
<td>5 Gb/s</td>
</tr>
<tr>
<td>10GBASE-T</td>
<td>Category 6A</td>
<td>500 MHz</td>
<td>10 Gb/s</td>
</tr>
</tbody>
</table>

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Remember!

**2.5GBASE-T** and **5GBASE-T** are only for **EXISTING** Cat 5e and Cat 6 cabling

<table>
<thead>
<tr>
<th></th>
<th>1000BASE-T</th>
<th>1000BASE-T</th>
<th>2.5GBASE-T</th>
<th>5GBASE-T</th>
<th>10GBASE-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Category 5e</td>
<td>Category 6</td>
<td>Category 5e/6</td>
<td>Category 5e/6</td>
<td>Category 6A</td>
</tr>
<tr>
<td>Speed</td>
<td>100 MHz</td>
<td>250 MHz</td>
<td>100 MHz</td>
<td>200 MHz</td>
<td>500 MHz</td>
</tr>
<tr>
<td></td>
<td>1 Gb/s</td>
<td>1 Gb/s</td>
<td>2.5 Gb/s</td>
<td>5 Gb/s</td>
<td>10 Gb/s</td>
</tr>
</tbody>
</table>

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1 Alien Crosstalk
2.5GBASE-T and 5GBASE-T

Alien Crosstalk

- Alien Crosstalk not specified for Cat 5e or 6 cabling
- Alien crosstalk limits also not specified for 2.5/5GBASE-T
  • HOWEVER, new criteria developed to assess channel’s susceptibility to AXT
- ALSNR (Alien Limited Signal to Noise Ratio)

  **ALSNR > 28 dB**
## 2.5GBASE-T and 5GBASE-T

### Alien Crosstalk

- **ALSNR testing to be implemented in field testers**
- **Field testing of AXT time consuming and expensive**
- **Summary of risk assessment based on bundled lengths**

<table>
<thead>
<tr>
<th>Bundle Distance (meters)</th>
<th>Speed</th>
<th>Cat 5e</th>
<th>Cat 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Victim Length (m)</td>
<td>Victim Length (m)</td>
</tr>
<tr>
<td></td>
<td>1 - 20</td>
<td>20 - 75</td>
<td>75 - 100</td>
</tr>
<tr>
<td>0 - 20</td>
<td>2.5G Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G Negligible Low Negligible Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 75</td>
<td>2.5G N/A Low Medium Low N/A Negligible</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G N/A Medium Low Medium High N/A Low Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 - 100</td>
<td>2.5G N/A N/A Medium N/A N/A Medium Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G N/A N/A High N/A N/A Medium High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Power over Ethernet (PoE)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Category</th>
<th>Bandwidth</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000BASE-T</td>
<td>5e</td>
<td>100 MHz</td>
<td>1 Gb/s</td>
</tr>
<tr>
<td>1000BASE-T</td>
<td>6</td>
<td>250 MHz</td>
<td>1 Gb/s</td>
</tr>
<tr>
<td>2.5GBASE-T</td>
<td>5e/6</td>
<td>100 MHz</td>
<td>2.5 Gb/s</td>
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<tr>
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<td>6A</td>
<td>500 MHz</td>
<td>10 Gb/s</td>
</tr>
</tbody>
</table>

### 3 Things You Need to Know About 2.5GBASE-T and 5GBASE-T

- **2.5GBASE-T** offers a higher bandwidth and speed compared to 1000BASE-T.
- **5GBASE-T** provides even higher data rates and is ideal for demanding applications.

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PoE is the most convenient method to power
  • Approximately 18 million PoE enabled APs shipping annually
    • 25 million by 2020
  • Power consumption increasing due to advanced technology

802.11ac WAP has faster speed but less coverage
  • More APs required, which means more cables
  • Potential issues with heat generation

Key considerations for network PoE capabilities
  • Ambient temperature, cable jacket rating, wire gauge and cable construction
**2.5GBASE-T and 5BASE-T**

PoE and Cable Bundle

Signal is weak but travels further = Less WAPs = Less Cable

Older devices have less antennas = Less power

↓

Low PoE

Small cable bundle
2.5GBASE-T and 5GBASE-T
PoE and Cable Bundle

Signal is strong but travels shorter = More WAPs = More Cable
Newer devices have more antennas = More power

High PoE
Large cable bundle

Limitations on 5e and 6 cable bundles
### 3 Things You Need to Know About 2.5GBASE-T and 5GBASE-T

#### 2.5GBASE-T
- Category 5e/6
  - 100 MHz
  - 2.5 Gb/s

#### 5GBASE-T
- Category 5e/6
  - 200 MHz
  - 5 Gb/s

<table>
<thead>
<tr>
<th>1000BASE-T</th>
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<th>2.5GBASE-T</th>
<th>5GBASE-T</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Category 5e/6</td>
<td>Category 5e/6</td>
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<tr>
<td>100 MHz</td>
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<td>1 Gb/s</td>
<td>2.5 Gb/s</td>
<td>5 Gb/s</td>
</tr>
</tbody>
</table>

### 802.11ax → 10 Gb/s

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  - September 24-28
  - Las Vegas, NV
2.5GBASE-T and 5GBASE-T
Only up to 5Gb/s
## Recommendations

### 1000BASE-T
- **Category 5e**: 100 MHz, 1 Gb/s
- **Category 6**: 250 MHz, 1 Gb/s

### 1000BASE-T
- **Category 5e/6**: 100 MHz, 2.5 Gb/s

### 2.5GBASE-T
- **Category 5e/6**: 200 MHz, 5 Gb/s

### 5GBASE-T
- **Category 5e/6**: 500 MHz, 10 Gb/s

### 10GBASE-T
- **Category 6A**: 500 MHz, 10 Gb/s

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Recommendations
2.5GBASE-T and 5GBASE-T Deployment

Brownfield

Understand limitations and challenges
• AXT, PoE, Cable Length and Bundle Size

Run cost and risk analysis
• Keep Cat 5e/Cat 6 or upgrade to Cat 6A

Upgrade to Cat 6A
• Cable, connectors, patch cords and panels

If existing Cat 5e/Cat 6 cabling is used, assess costs associated with mitigation strategies before implementation
• Test for ALSNR $
• Unbundle TR patch cords $
• Consider replacing TR patch cords with Cat 6A $
• Consider replacing TR patch panels and connectors with Cat 6A $
• Consider unbundling horizontal cables $

Material $ = System Labor $ = Longevity $ = Roii

New Cat 6A Vs. Existing Cat 6/5e
Recommendations

Greenfield

Use Cat 6A
Plan for future
  • TIA TSB-162-A

802.11ac Cabling Structure
Based on a 60 sq ft Uniform Cell Size

- WAP Cord: Max = 13m (42ft)
- 6A Cable: Max = 80m (262ft)
- Equip. Cord: Max = 6m (20ft)
Four Steps to Successful Wireless Deployment

**STEP 1**
Understand Wireless Technology

**STEP 2**
Understand Applications and Capacity

**STEP 3**
Understand Environments and Architecture

**STEP 4**
Make Cabling and Connectivity Choices

**Category 6A Offers the Best Solution**
for enterprise applications seeking system longevity, faster data transfer, and support for high-bandwidth wireless networks.
Questions?