Cisco Medical Grade Network Campus Architectures

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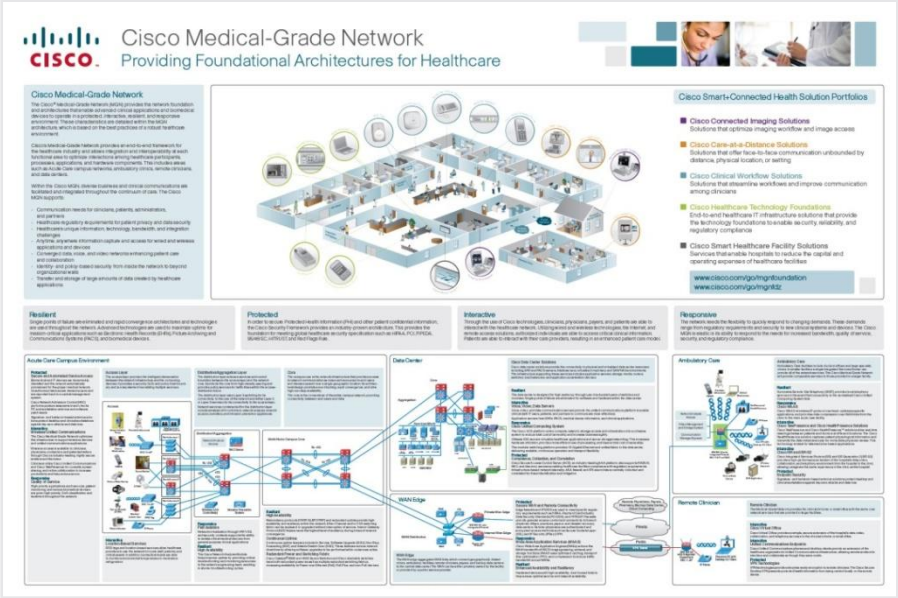
What Is the Cisco Medical-Grade Network?

- The Cisco Medical-Grade Network is an optimized architecture for the healthcare industry based on Cisco's best practices for security, campus, data center, remote office, and wireless networks
- The Cisco MGN 2.0—campus architecture:
  - •Industry-specific framework following a set of proven best practices
  - •Provides a mapping of clinical and business needs to technology solutions
  - •Optimizes interactions between processes, applications, and technical architecture components
  - •Facilitates business and clinical communications throughout the continuum of care
  - •Enhances collaboration across the technology partner ecosystem



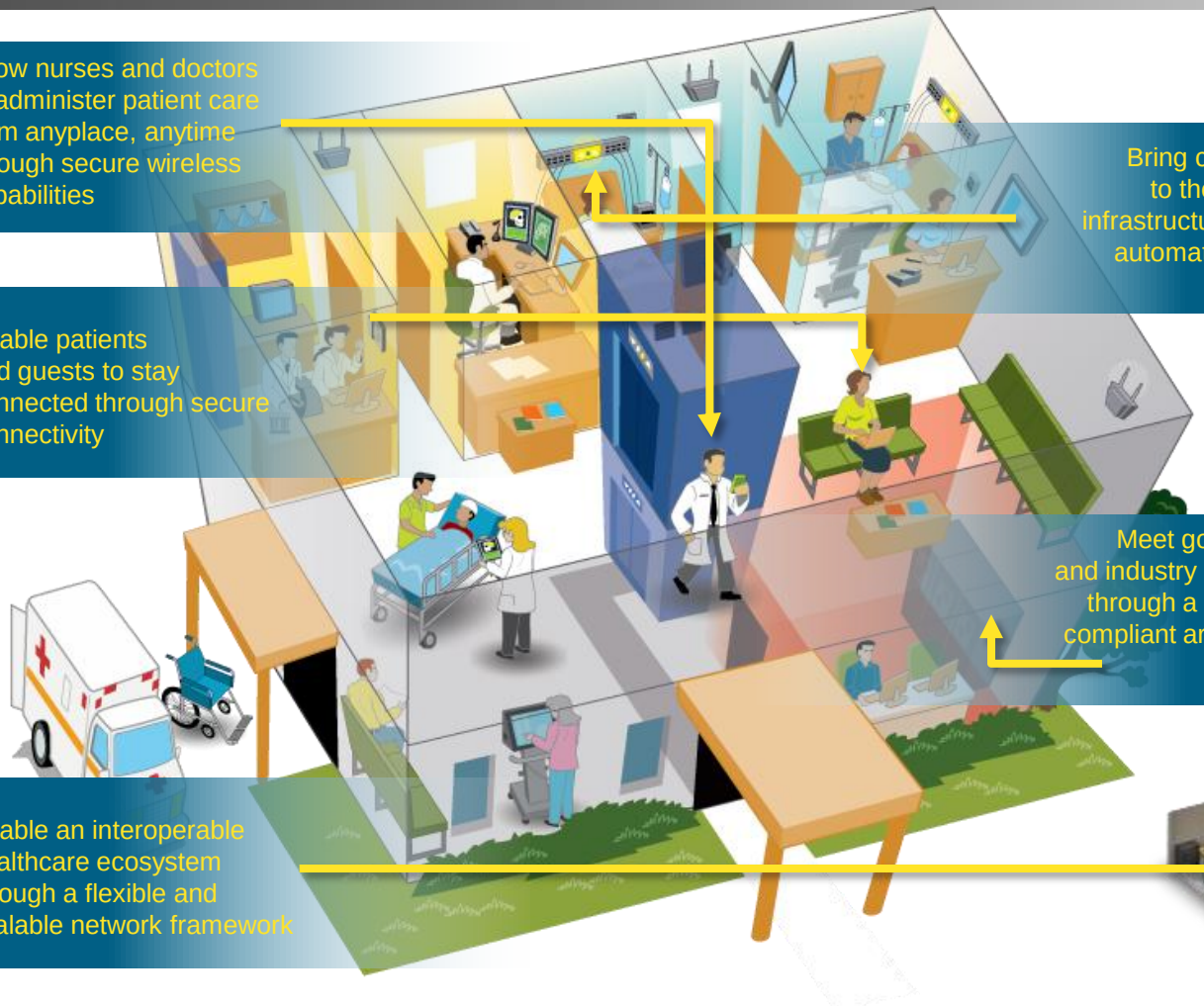
Cisco's Medical-Grade Network Framework for Healthcare

Enabled by Borderless Networks

Allow nurses and doctors to administer patient care from anyplace, anytime through secure wireless capabilities

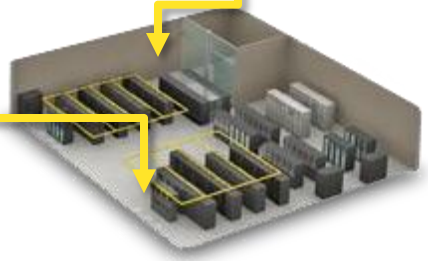
Enable patients and guests to stay connected through secure connectivity

Enable an interoperable healthcare ecosystem through a flexible and scalable network framework



Bring connectivity to the hospital's infrastructure through automated biomed devices

Meet government and industry mandates through a regulatory compliant architecture (ex: PCI)



Data Center

Cisco Medical-Grade Network Goals

Resilient

- Fault-tolerant and capable of business continuity
- No single point of failure
- Rapid convergence

Protected

- Protection for any patient data on rest and in transit
- Compliant with regulatory requirements
- Posture for each device with ePHI access

Responsive

- Network adapts to change and business/ clinical needs
- Has ability to incorporate new technologies

Interactive

- Ability of care providers and vendors to interact with net seamlessly
- Wireless, VPN extends net into BN
- Integrates data, voice, video and imaging

Cisco Medical-Grade Network 2.0

Biomedical Devices

Considerations in Campus Requirements

- Unique Layer 2 and Layer 3 requirements

  Many vendors require separate parallel Layer 2 VLANs

  Layer 3 and multicast functionality may be limited

- Traffic Flows Vary

  Patient monitors: Small (300 byte), but frequent (4x/sec) broadcasts, multicasts or unicast (vendor-specific)

  IV pumps: Formulary and firmware updates are usually small and not a daily occurrence

  Biomedical devices often communicate back to central monitoring station

- SLA Requirements

  Prevent < 50ms jitter

  Maintain < 20ms connectivity loss from patient monitor to central station

- Path Isolation may be required

Patient Monitors

Patient Monitors
Provides real time monitoring of vital signs (blood pressure, oximetry etc) on continuous basis. May connect to central station

IV Pumps

Infusion (IV) Pumps
Administers medication to patients and requires formulary and drug library updates on an intermittent basis.

Radiology Devices

Portable Radiology Devices
Connects to the RIS and PACS system.

Biomedical Devices Wireless considerations

Wireless Challenges

- Special RF Requirements
  - Vendor specificic requirements for 802.11 a/b/g/n usage
  - Dedicated SSIDs interference elimination recommendations, etc.
- Varying Authentication/Encryption Methods
  - WEP, WPA, WPA2
  - 802.1x not common on today's biomedical devices
- Unique Layer 2 (L2) and Layer 3 (L3) requirements
  - Many vendors require separate parallel Layer 2 VLANs
  - Layer 3 and multicast functionality may be limited
  - A 1:1 SSID/VLAN mapping generally required or recommended
- Traffic Flows Vary
  - Patient monitors: small (300 byte), but frequent (4x/sec) broadcasts, multicasts or unicast (vendor-specific)
  - IV pumps: formulary and firmware updates are usually small and not a daily occurrence
  - Biomedical devices often communicate back to central monitoring station
  - Portable radiology devices store studies on the PACS while the device is in use at the point of care

Patient Monitors

Patient Monitors

Provides real time monitoring of vital signs (blood pressure, oximetry etc) on continuous basis.

IV Pumps

Infusion (IV) Pumps

Administers medication to patients and requires formulary and drug library updates on an intermittent basis.

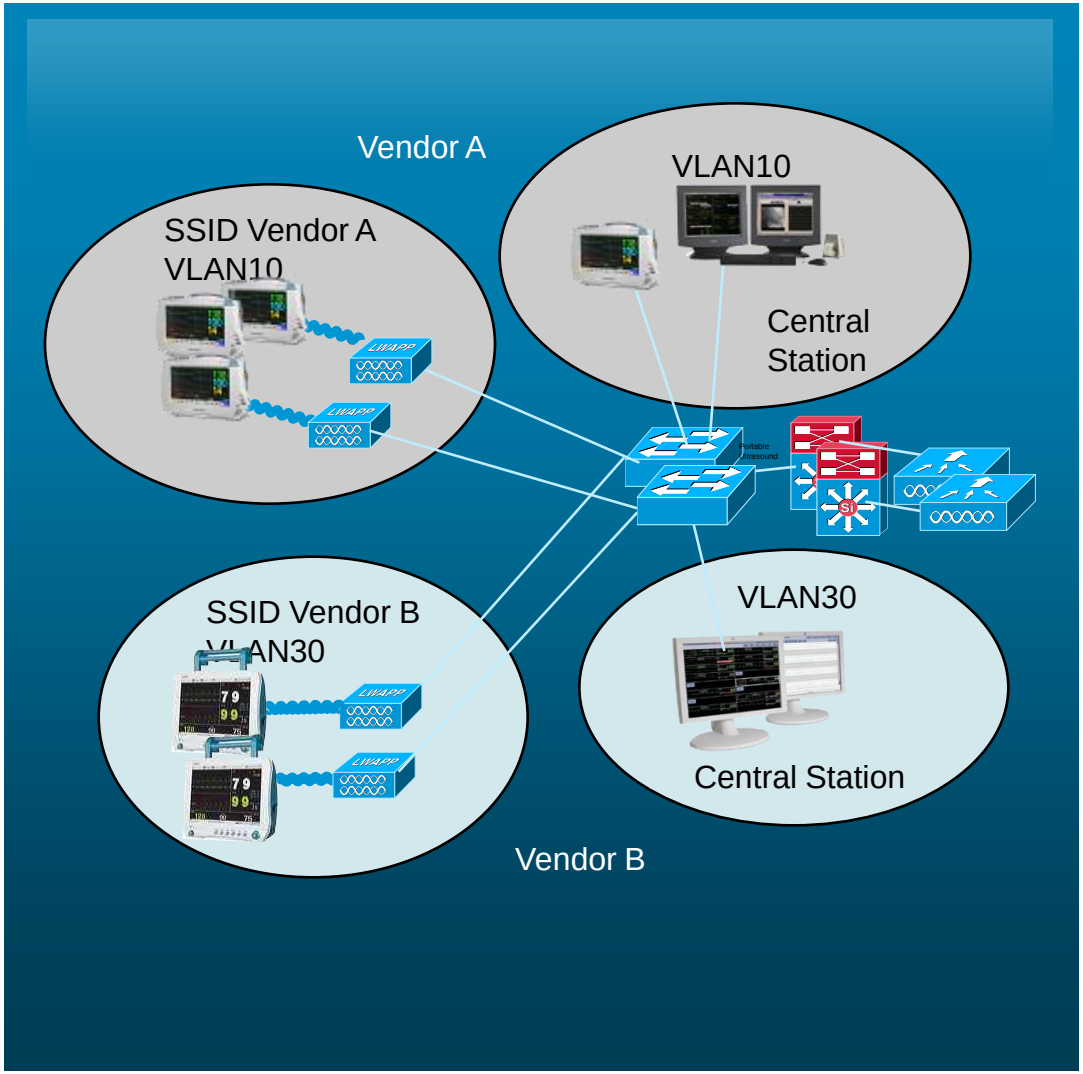
Radiology Devices

Portable Radiology Devices

Provide wireless connectivity to the RIS and PACS system. Eliminate delays in storing studies acquired at point of care.

Patient Monitor Wireless Guidelines

- RF Requirements
  - 1:1 SSID/VLAN mapping
  - 25 dB min SNR co-channel separation
- Authentication and Encryption
  - Utilize WPA or WPA2
- Unique Layer 2 and Layer 3 requirements
  - Dedicate separate VLAN for each patient monitor vendor type
  - Layer 3 and multicast functionality may be limited
- SLA Requirements
  - Prevent <50ms jitter
  - Maintain <20ms connectivity loss from patient monitor to central station, QoS !!!



What's Available and on the Horizon

Mobile Units

Desktop Video

Mobile Devices

Stationary Care

Patient comes to the clinic

Mobile Care

Care comes to the patient

Tandberg Carts

Desktop care

Low cost

Low-bandwidth

SmartPhones

Wireless Tablets

Mobility

Clinical Systems

Wireless Challenges

- Legacy applications intolerant of connectivity loss due to signal or roaming issues

  If designed for LAN and not tuned for WAN/VPN/WLAN some applications may fail to respond or recover

- Wide range of implementations/ requirements

  Even within a single vendors product line bandwidth, security, chattiness, delay tolerance may vary

- Patient privacy

  Protected Health Information (PHI) will be in the data transmitted across the network

  Access security and encryption must be used end-to end

- Varied Wireless Client RF Characteristics

  Wireless clients of different models or vendors may have significantly different roaming or receiver sensitivities

CoWs

Computers on Wheels (CoWs)

Carts built specifically for the healthcare market with on board computers that run clinical applications

General Computing Devices

General Purpose Computing Devices

General purpose tablets, laptops, and computers with clinical applications loaded

Smart phones/ PDAs

Smartphones/PDAs

Smartphones or PDAs (typically owned by the clinician) used to access clinical applications

complete

Healthcare Requirements in Campus

Clinical App Requirement

Biomedical Devices

- Mission critical
- Some layer 2 adjacency demands, L3 considerations
- Central station connectivity requirements
- Endpoint security

Clinical Devices and Systems

- Mission critical
- Jitter/latency demands
- HIPAA and privacy
- Wired and wireless considerations

Medical Grade Network

Medical Grade Network

- Highly availability (fast recovery and convergence)
- Path isolation
- Flexible L2 and/or L3 to access
- Network access control and Identity based

- Highly availability (fast recovery and convergence)
- Protection of ePHI and clinical systems
- Compute/storage/virtualization within Data Center

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Healthcare Requirements in Campus

Clinical App Requirement

PACS and Modalities

- Large image transfer
- Storage demands
- Quick access/retrieval
- Geographically remote modalities

Medical Grade Network

- High throughput
- High availability
- Compute/storage/virtualization within Data Center

Regulatory and Security

- HIPAA/joint commission
- Payment card industry
- Local country regulatory (EC 95/46)
- IEC-80001
- Fulfilling meaningful use requirements

- Intrusion prevention and patch management
- Device identity and access control
- HiTRUST
- Cisco security intelligence operations

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Healthcare Requirements in Campus

Clinical App Requirement

Guest Services

- Wireless
- Network access control
- Acceptable use policy
- Visiting physician access

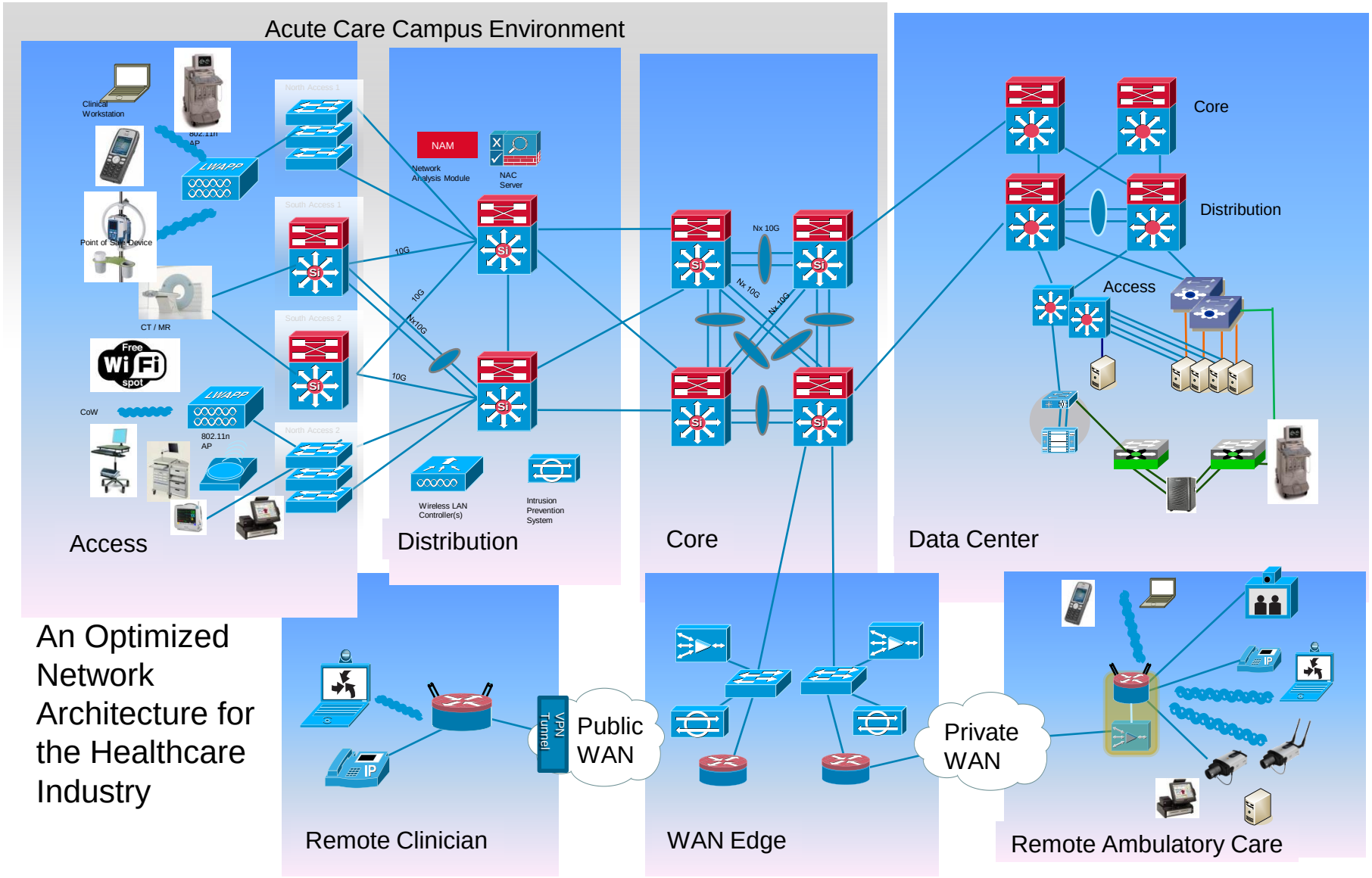
Medical Grade Network

- Internet access and logical segmentation
- Network admission control
- Posture assessment
- Acceptable use policy

- Voice/Video/Collaboration
- Emerging trends
  - Medical device integration
- Cisco Healthcare solutions
  - HMI collaboration, Nurse Connect
  - Biomed NAC, Health Presence etc

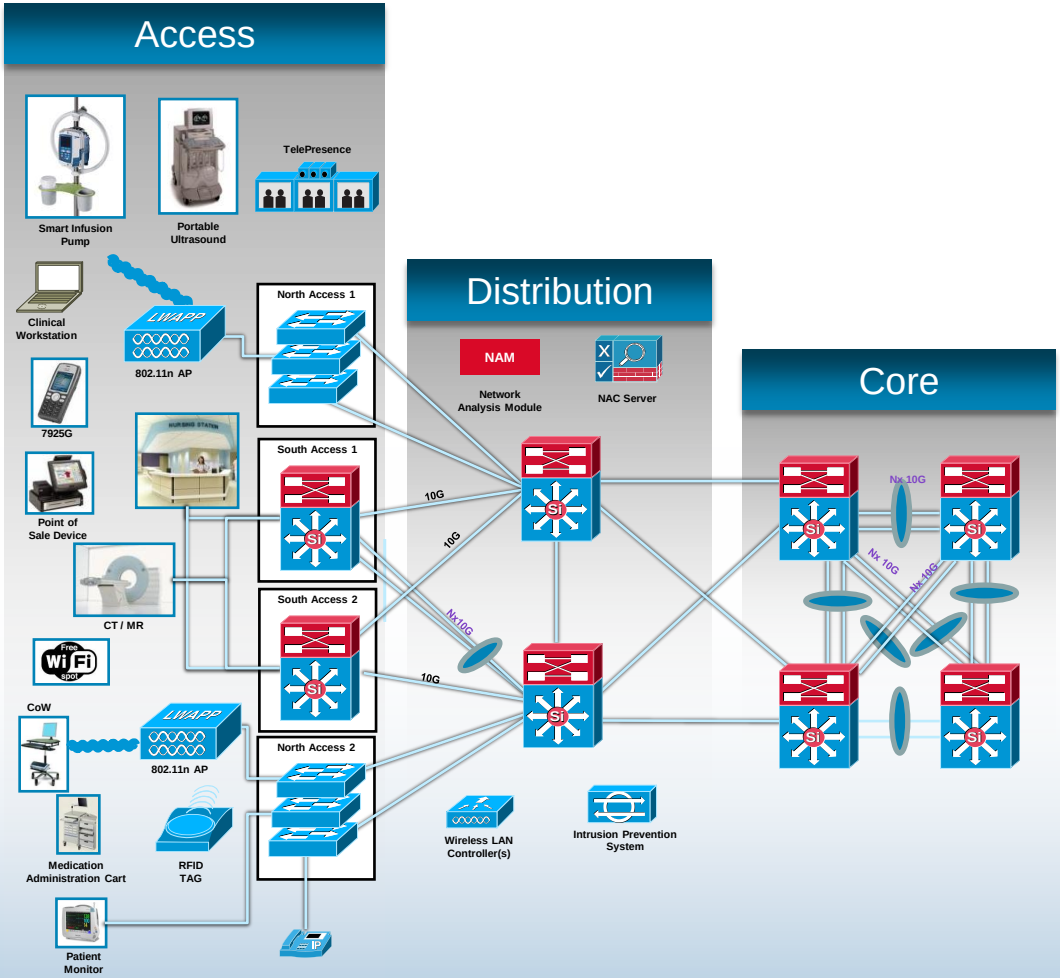
- Quality of service
- Network responsiveness
- Network interactivity
- Modular design

Cisco Medical-Grade Network Overall Campus Architecture

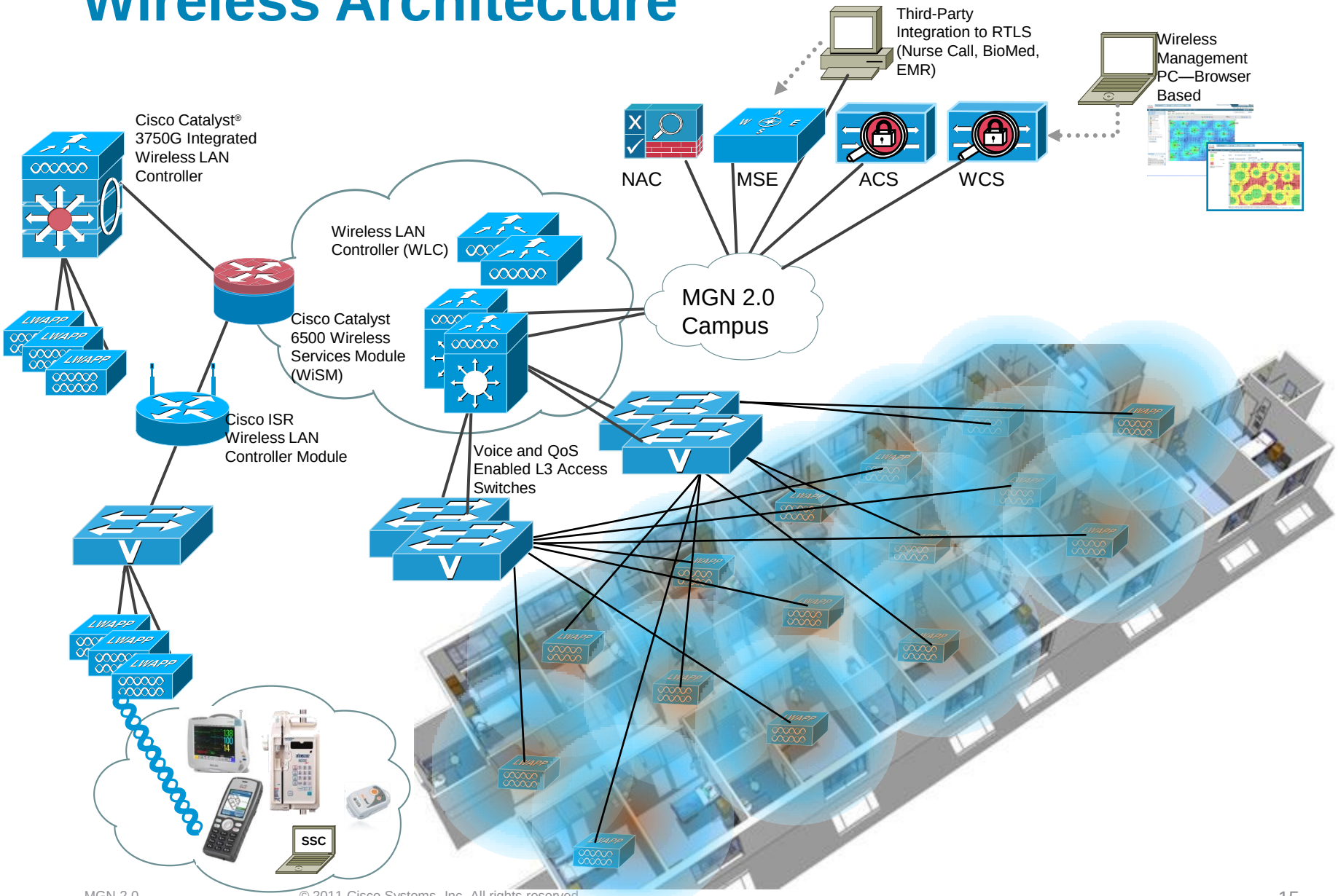


Cisco Campus Architecture in Healthcare

- Hierarchal designs
- No single points of failure
- Utilize in box redundancy
- Optimize convergence
- Best practices must adapt to unique healthcare requirements
- R&S enables such interconnection
- Legacy Apps and devices result in suboptimal, overlay design, often dedicated networks



MGN 2.0
Wireless Architecture



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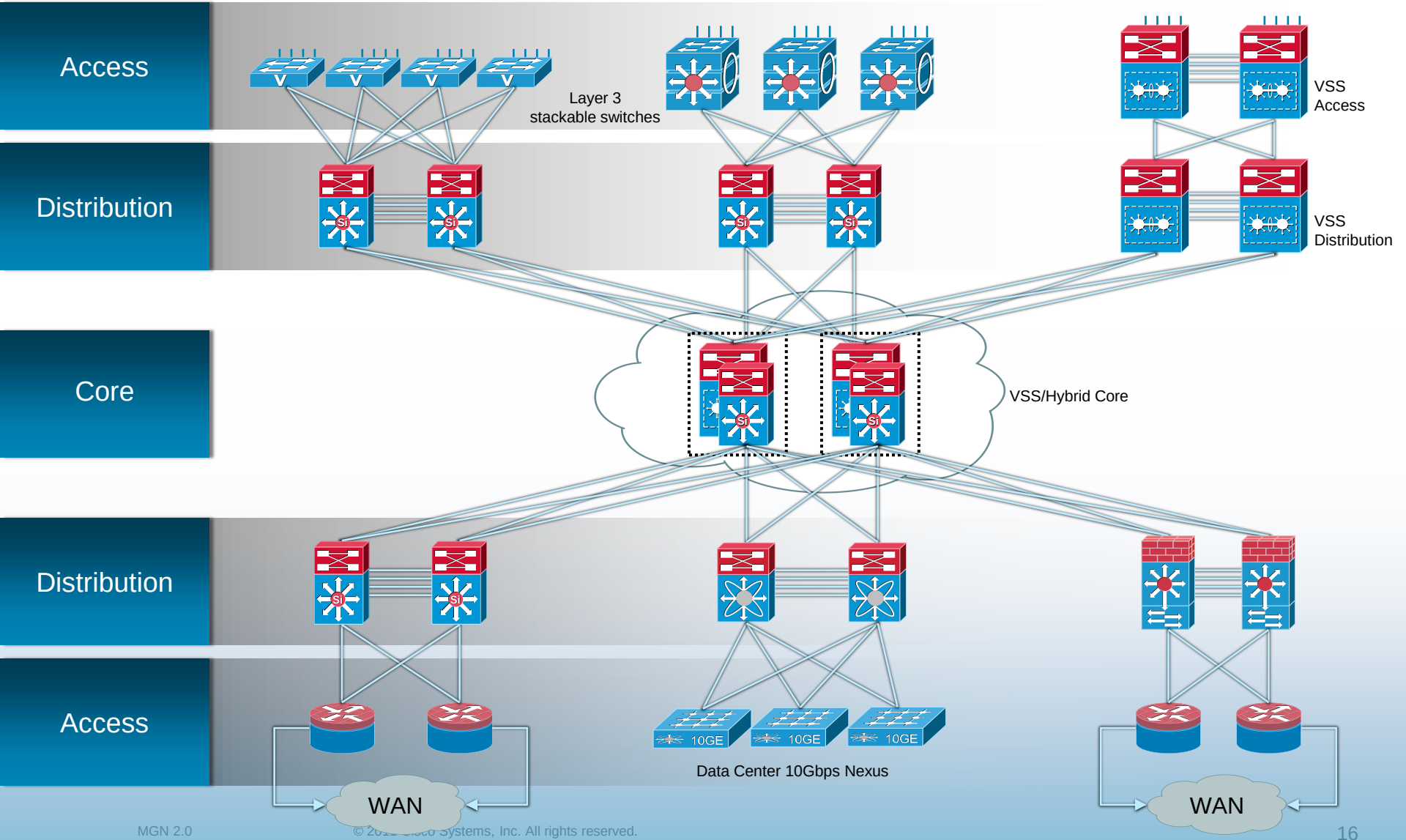
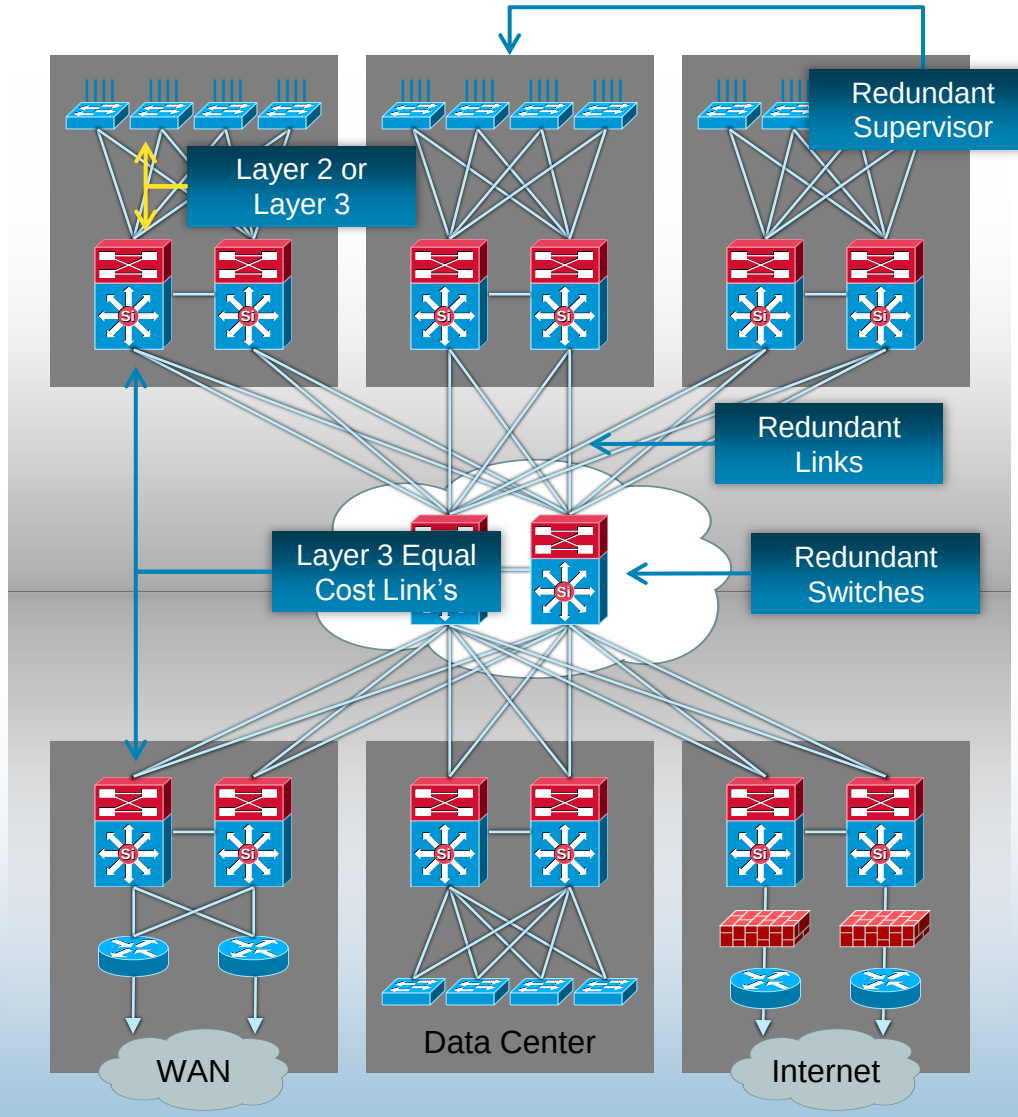
Cisco MGN 2.0 Campus Design

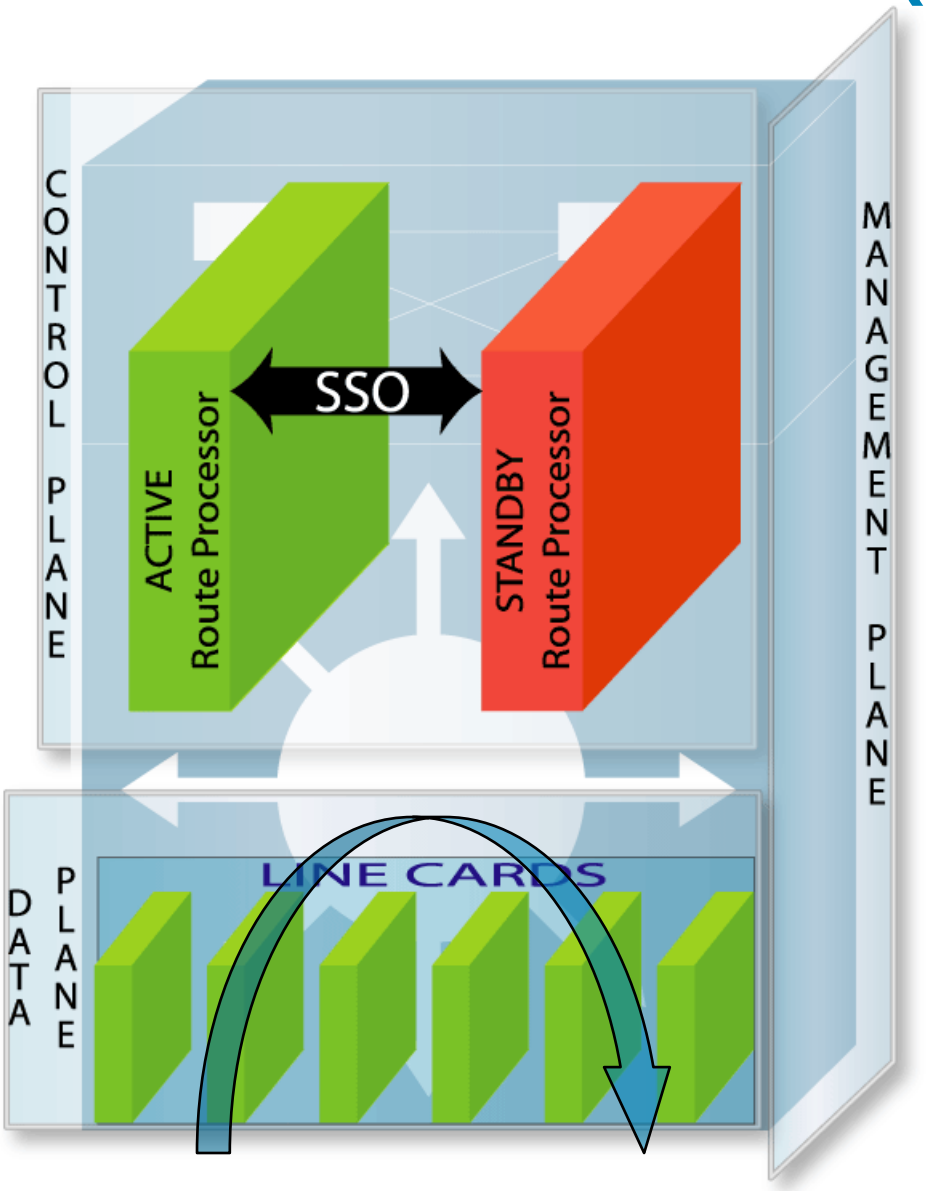


MGN High Availability Campus Design

- Eliminate all single points of failure
  - Implement hierarchical designs
  - Utilize redundant chassis or smart stackable switches
- Redundant switching and power fabrics
- In the box and network redundant services
- Utilized IGP protocols that quickly detect faults and provide sub-second failover



Supervisor Redundancy Is Provided by Stateful Switch Over (SSO)

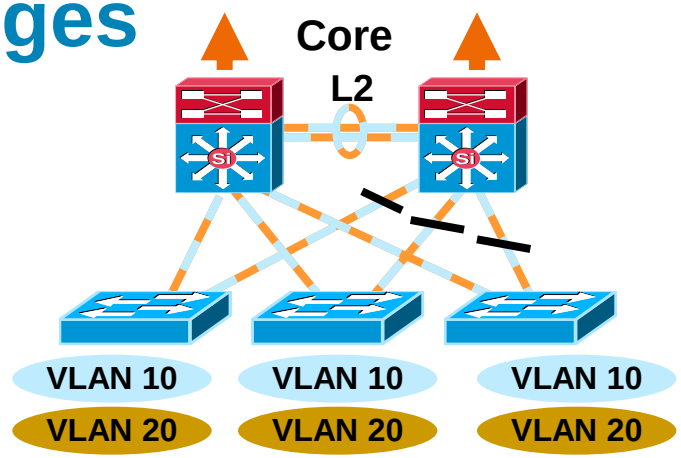


- Active/Standby supervisors run in synchronized mode
- Depending on platform, line card and protocol this incurs from 0 to 3 seconds of outage
- Switch processors synchronize Layer 2 and Layer2 / Layer 3 FIB, QoS and ACL tables
- Line cards with DFC are populated with Layer 2 / Layer 3 routing information and ACL tables
- Line card protocol status is maintained during failover reducing impact and improving clinical access

Healthcare Campus Challenges

Age Old Problem

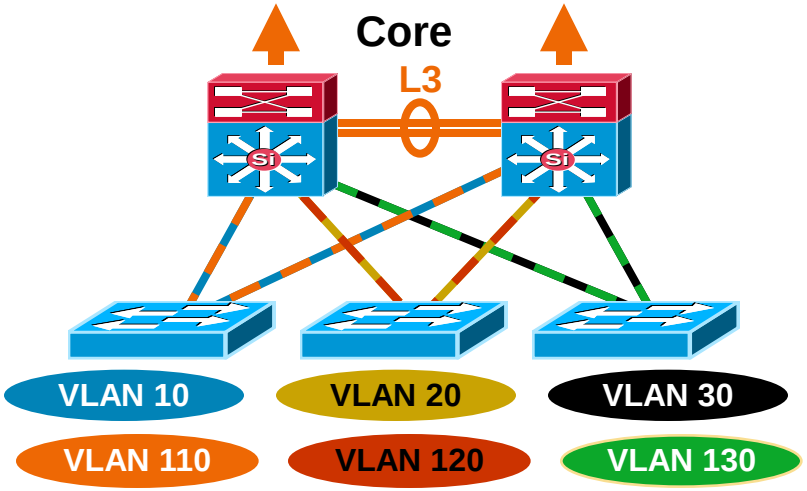
- Remember old days of flexibility, add/move and mobility promise?
- Spanning VLAN solved that and created some more problems of
  - Stability
  - Response times
  - Inefficient use of resources
  - Managing end host behavior



Looped Topology
All VLANs spans All Access-switches

Historically —A Compromise

- Do not span VLANs.
- No Loops no underlying threat to the network
- Solution gave up critical need of not able to span VLANs.
- However, in many healthcare deployments, clinical and biomedical devices requires vendor dedicated VLANs

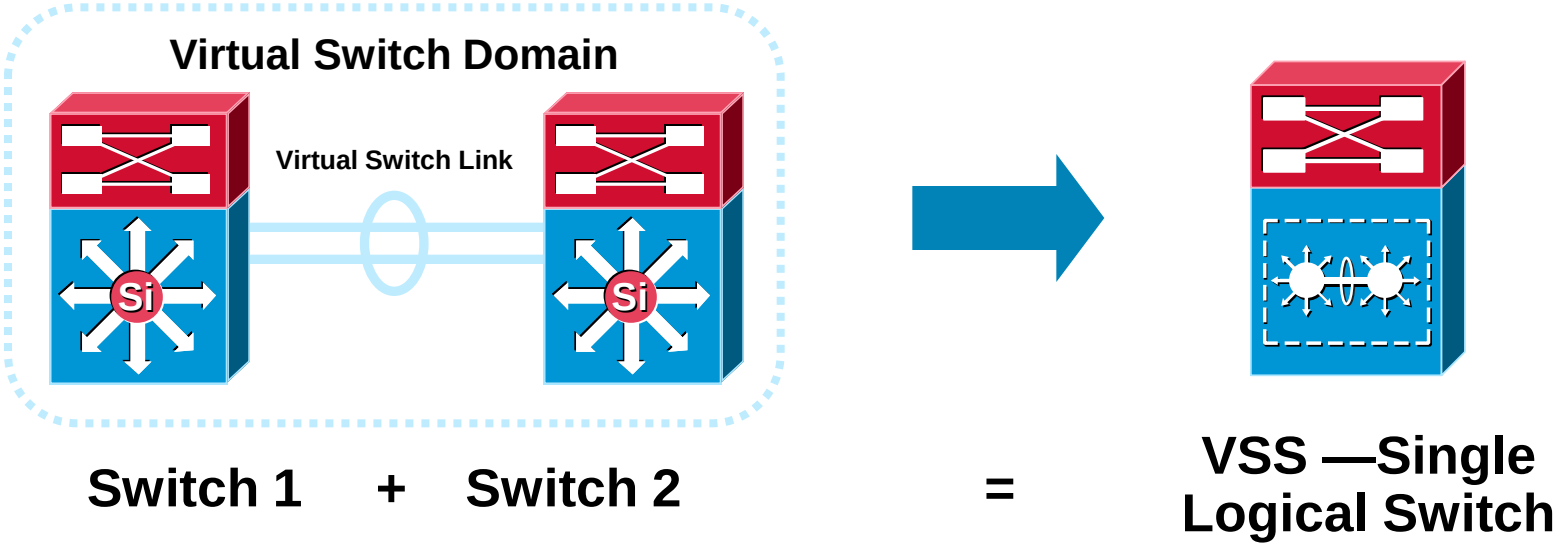


Loop Free Topology
VLAN = Subnet = Closet

Virtual Switch

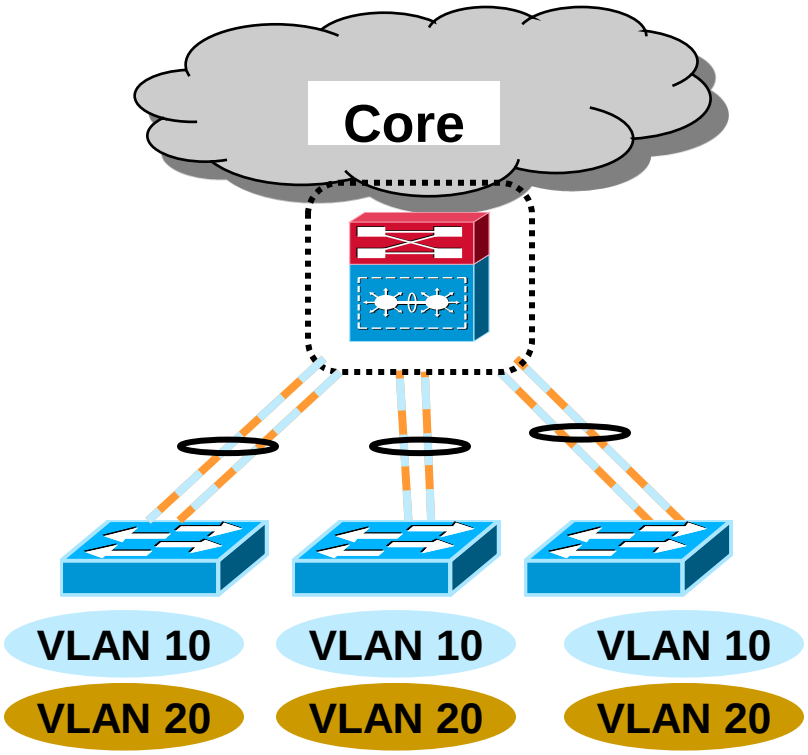
Virtual Switching System 1440 (VSS)

- Virtual Switching System consists of two Cisco Catalyst 6500 Series defined as members of the same virtual switch domain
- Single control plane with dual active forwarding planes
- Design to increase forwarding capacity while increasing availability by eliminating STP loops – a loop-free topology
- Reduced operational complexity by simplifying configuration



Virtual Switching

- Solving the same **old** design problem and yet not loose the benefits of stability and mobility
- Virtual Switching allows elimination of loops in the network, while allowing for spanning of VLANs



VSS Enabled Loop Free Topology
VLANs spans Access-switches

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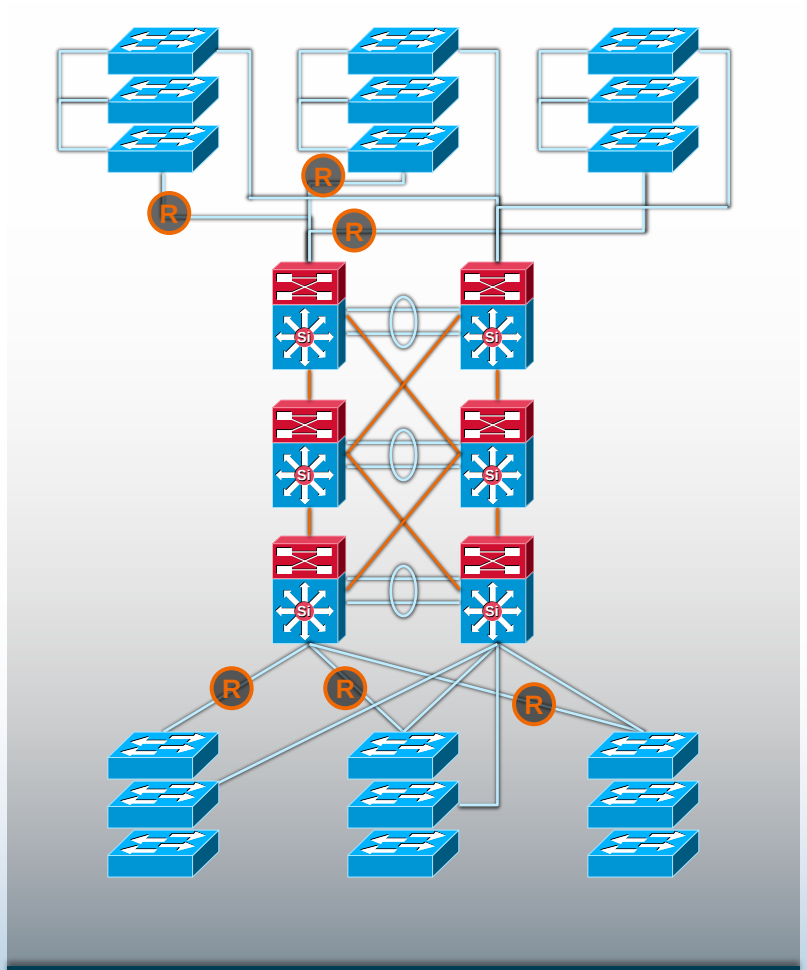
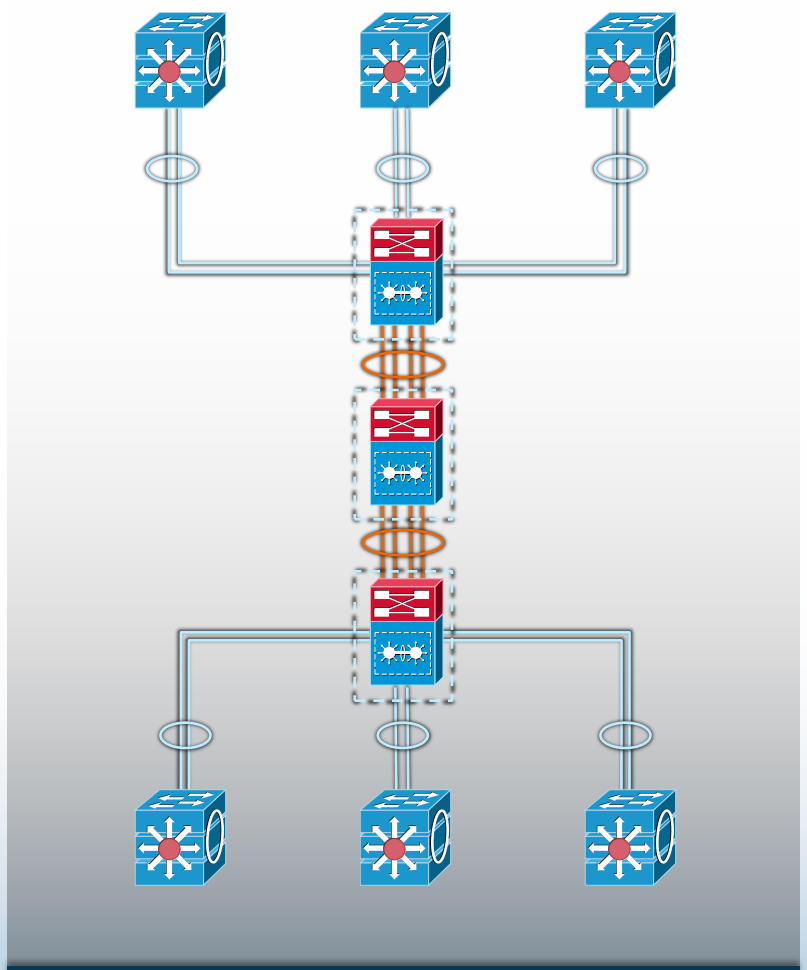
VSS Enabled Healthcare Campus Design

End-to-End VSS Design Option



STP-based Redundant Topology

R = STP Blocked Link

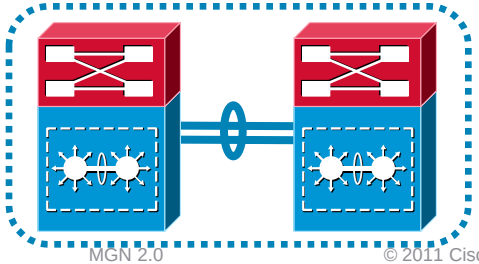


Fully Redundant
Virtual Switch Topology

Three Options for Multi-Chassis EtherChannel Designs to Remove Spanning Tree

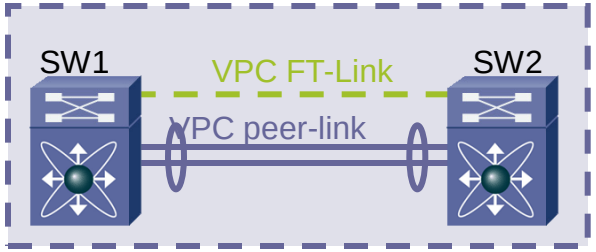
Virtual Switching System

- Single control plane
- Single management plane
- Single supervisor per chassis
- Automatic port config sync (single control plane)
- Single L3 domain (single SVI) **no need for FHRP**



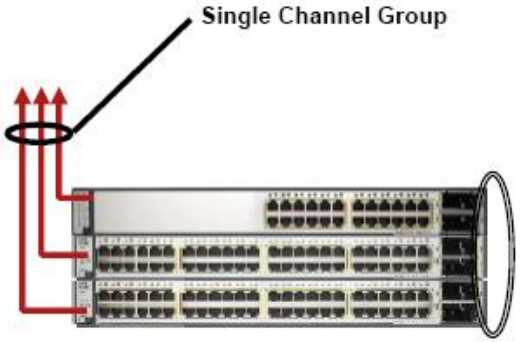
Virtual Port Channel

- Separate control plane
- Separate management plane with VPC state synchronization (CFS)
- Redundant supervisors per chassis with hitless SSO
- Manual port sync config (DataCenterNetworkMgr)
- Local SVI **HSRP/PIM forwarding enhancements to act as active-active pair**



Stackwise+

- Single control plane controlled by Master Switch
- Master switch controls etherchannel
- Redundant master switches per stack
- Automatic port config sync (single control plane)
- Stack appears as a single router, **no need for FHRP**



Campus Design Option: VSS

Key Benefits to Healthcare Providers

- Eliminates complexity of Spanning Tree Protocol and prevents potential for loops in network.
- Faster failover by eliminating need for gateway redundancy protocols (HSRP, VRRP, GLBP)
- Simplified network management (less links/configuration, fewer operational points)
- Conserves bandwidth (no unicast flooding, MEC optimizes number of hops

Environmental Considerations

Power

- Separate grid based power feeds
- Building based Backup Generator Power
- Localized UPS Power especially for PoE deployments
- Redundant Power Supplies

Cooling

- Examine BTU generation compared to HVAC systems
- Redundant HVAC chillers on separate power
- Consider rRack design for front to back vs side to side airflow

Physical Security

- Monitor and maintain access to IT infrastructure
- Log access to key distribution areas
- Utilize video surveillance
- Take precautions to prevent unauthorized access and prevent data loss

Cisco Connected Real Estate for Healthcare:

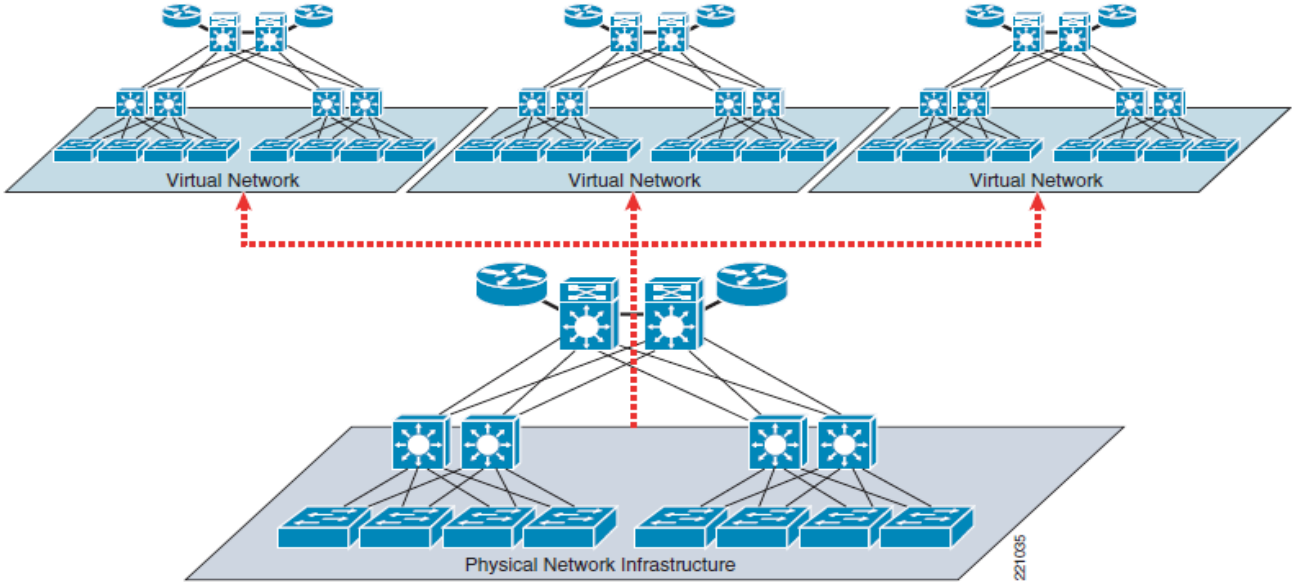
Monitoring

- Use 802.11 based thermal & humidity monitoring
- Implement smart building technologies (Cisco Connected Real Estate) for power and cooling monitoring
- Track battery health for localized UPS devices
- Utilize under floor water detectors

Cisco Medical-Grade Network 2.0

Convergence of Biomedical and General Purpose IT Networks

- In the past – biomedical devices lived on dedicated networks/frequencies, no IT connection
- Biomedical devices very expensive – no HA
- Vendors touch IT networks – adoption IP and Eth
- Due to the regulatory and vendor restrictions – results in unpatched OS running critical apps
- Biomedical devices very fast populate IT networks – Network Virtualization and Path Isolation Requirements in Healthcare Networks !!!



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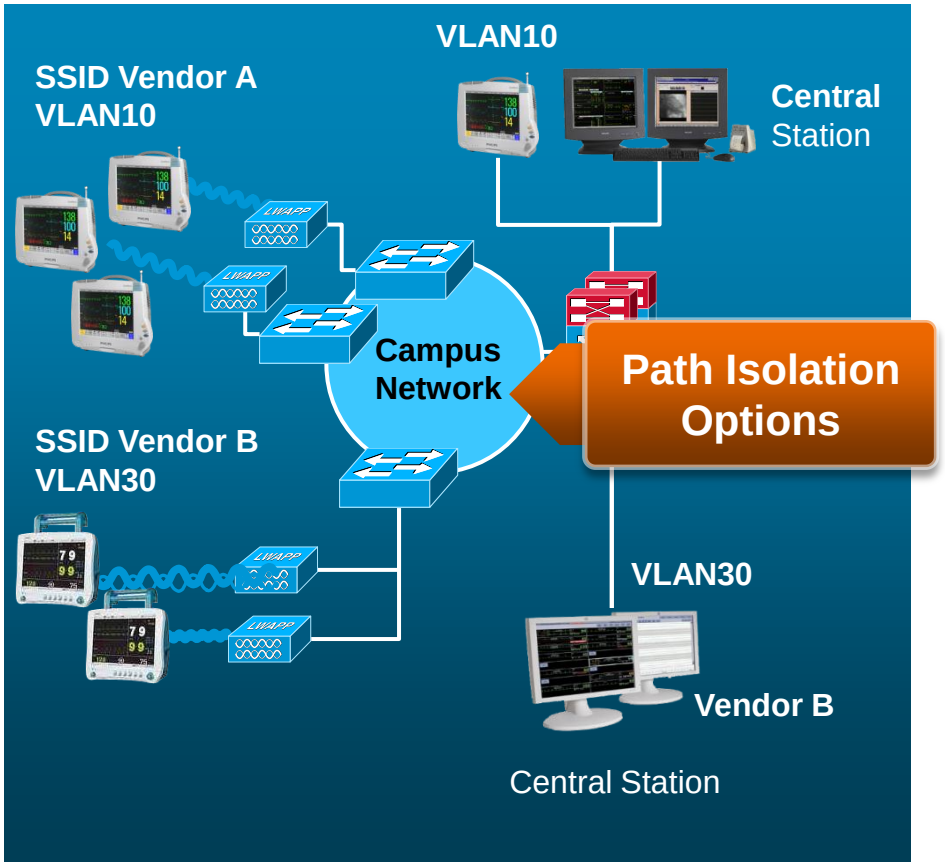
Biomedical Devices Path Isolation Options

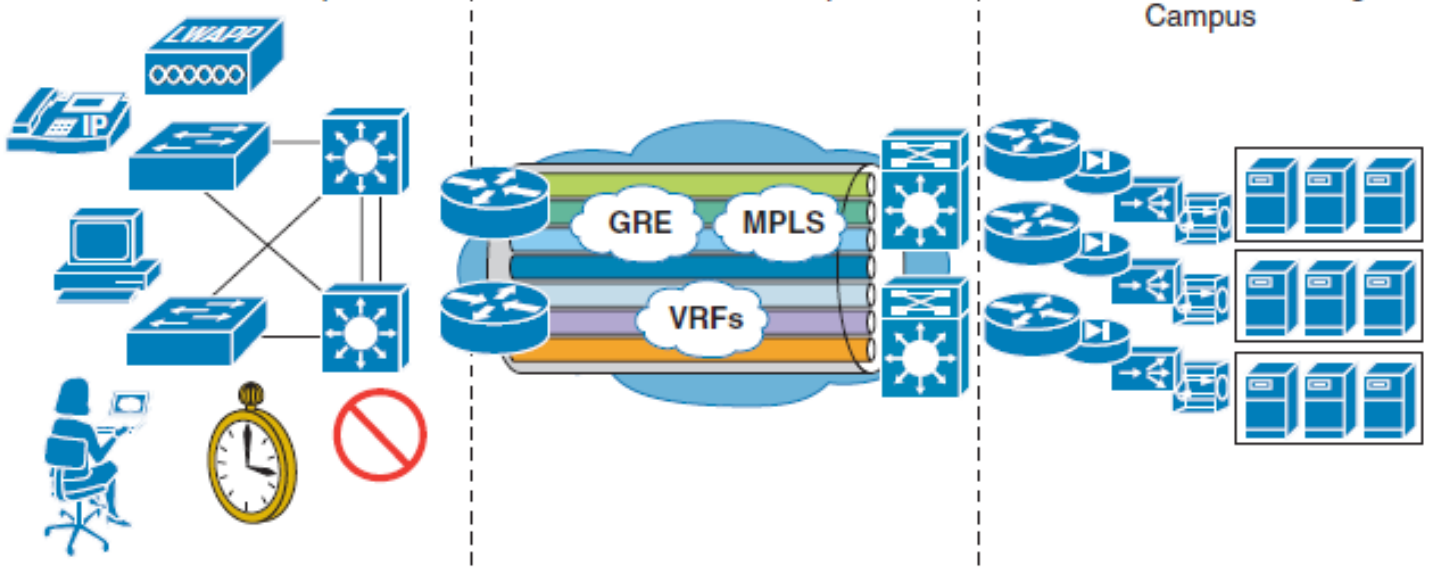
- Generic Routing Encapsulation (GRE) Tunneling
  - Create Closed User Groups
- Virtual Routing and Forwarding (VRF-lite)
  - Lightweight
  - Single routing device
- Multiprotocol Label Switching (MPLS)
  - Cisco Catalyst 6500
- Overlay Transport Virtualization (OTV)
  - Emerging Technology in Data Center



For More Information:
http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/PathIsol.html

Functional Elements in Virtualized Campus Networks

	Access Control	Path Isolation	Services Edge
	Branch - Campus	WAN – MAN - Campus	Data Center - Internet Edge - Campus
Functions	Authenticate client (user, device, app) attempting to gain network access Authorize client into a Partition (VLAN, ACL) Deny access to unauthorized clients	Maintain traffic partitioned over Layer 3 infrastructure Transport traffic over isolated Layer 3 partitions Map Layer 3 Isolated Path to VLANs in Access and Services Edge	Provide access to services: Shared Dedicated Apply policy per partition Isolated application environments if necessary



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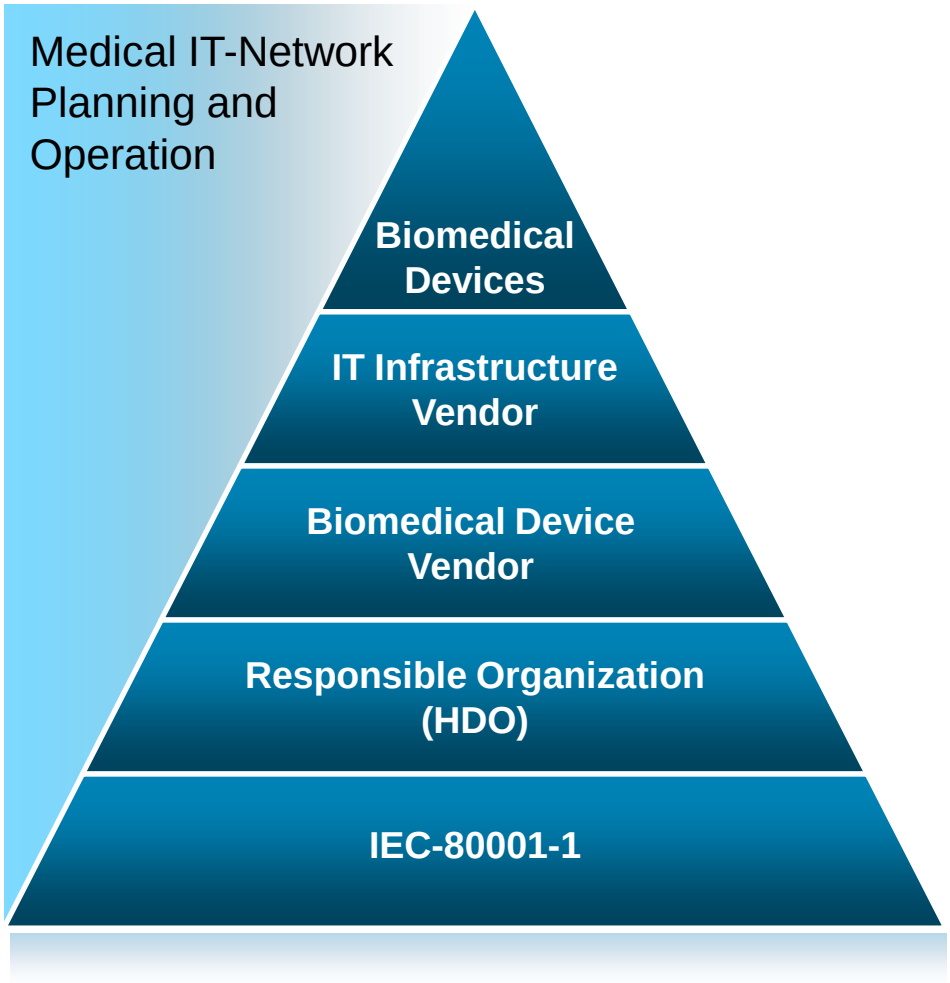
IEC 80001: Application of risk management for IT-networks incorporating medical devices

- IEC-80001 is a voluntary international standard, dealing with risk management of IT networks incorporating medical devices
- Provides framework for the “Application of risk management for General purpose IT-networks incorporating medical devices”
- Three “Key Properties”—Safety, Effectiveness, Data and System Security
- Four supplementary documents or Technical Reports (TR’s) in development:
  - Wireless Guidance
  - Healthcare Delivery Organization (HDO) Step-by-Step guide
  - Security Guidance
  - HDO Implementation Guidance



QoS in Healthcare

- Convergence of medical systems onto a common network with ubiquitous access to info rises the potential network congestion and app failure
- Clinical Apps
- Medical Devices
- PACS
- Voice
- Video and Collaboration
- Network Control Protocols
- Device Control Protocols
- Guest Services
- Standard IT Traffic
- **QoS necessary … !!!**

Medical Grade Network QoS Classifications

Application Class	Per-Hop Behavior	Queuing and Dropping	Medical Applications
Network Control	CS6	BW Queue	
VoIP Telephony	EF	Priority Queue (PQ)	Constant Bit Rate Biomed Feeds
Broadcast Video	CS5	(Optional) PQ	
Realtime Interactive	CS4	(Optional) PQ	Cisco Healthcare, Telepresence
Multimedia Confrencing	AF4	BW Queue + DSCP WRED	Cisco Unified Personal Communicator
Multimedia Streaming	AF3	BW Queue + DSCP WRED	*Biomedical Telemetry Steaming
Call-Signaling	CS3	BW Queue	
Ops/Admin/Mgmt (OAM)	CS2	BW Queue	
Transactional Data	AF2	BW Queue + DSCP WRED	*Biomedical Devices, Critical Apps, WebEx
Bulk Data	AF1	BW Queue + DSCP WRED	PACS, Large File Apps
Best Effort	DF	Default Queue + RED	Back Office, Archiving, Patient Records
Scavenger	CS1	Min BW Queue (Deferential)	Guest Traffic

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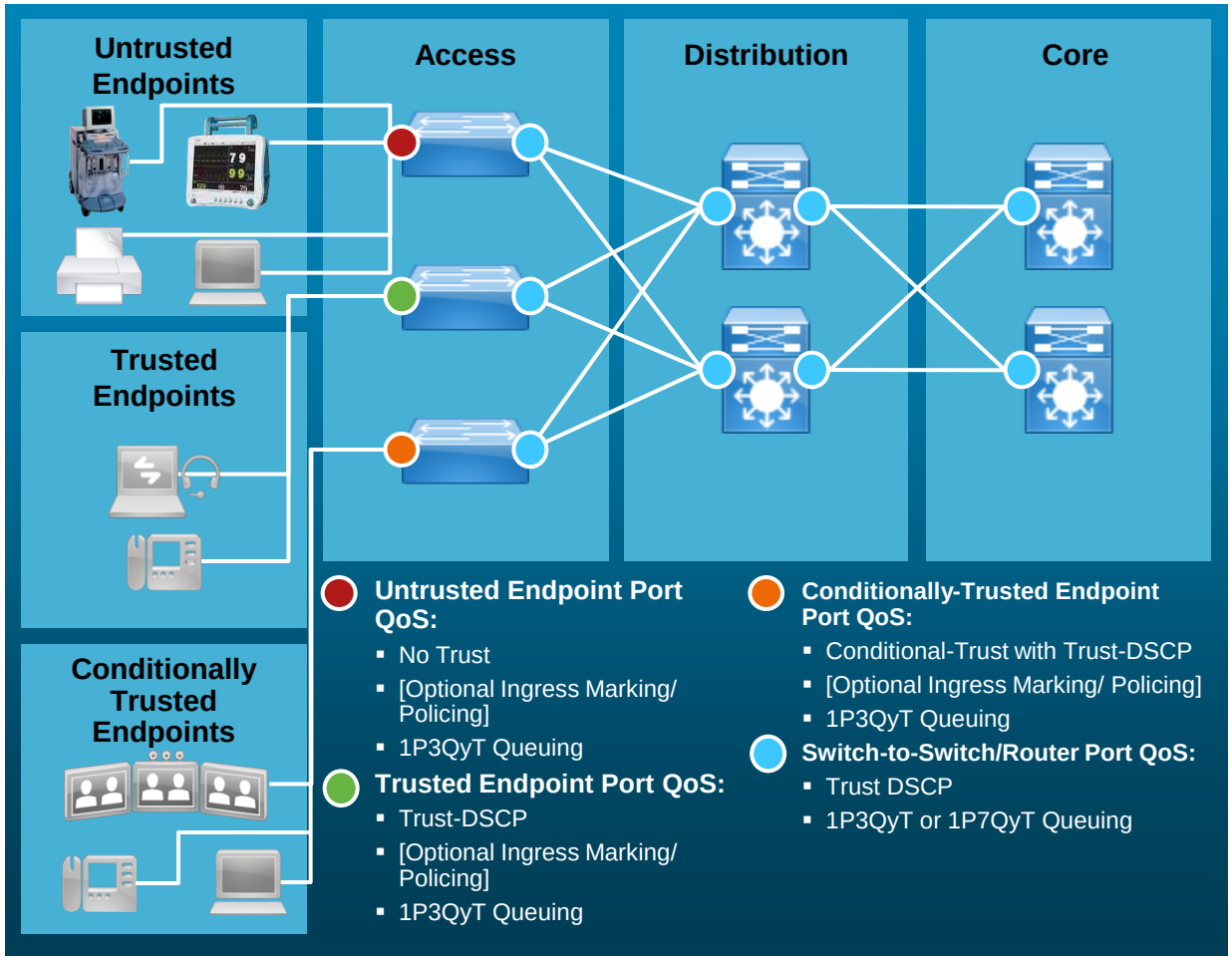
QoS Boundaries

- Summary of trust, marking, policing and queuing boundaries
- Correct Trust and Markings at Access
- Interswitch links in Campus will trust DSCP markings
- Perform Policing and Queuing where appropriate



For More Information:
http://www.cisco.com/en/US/docs/solutions/Enterprise/WAN_and_MAN/QoS_SRND_40/QoSCampus_40.html

Campus Voice and Collaboration Considerations

Challenges

- In Order to Provide Optimal Patient Care, Collaboration Among Caregivers is Essential
- Due to the Critical Nature of the Collaboration both the Campus Infrastructure and the Collaboration Systems Must be Constantly Available
- The Diversity of Caregivers Requires that a Wide Range of both Wired and Wireless Endpoints Must Be Supported

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Campus Voice and Collaboration Considerations

- Power over Ethernet
  - Switches
  - End Points
- Voice over WLAN
  - VoWLAN QoS
  - Multicast
- Unified Communication
  - UC Manager Resiliency
  - Security
  - Session Manager Edition
  - SRST

PoE Devices

IP Phone Portfolio

For More Information:
http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/PathIsol.html

Voice over Wireless LAN

Wireless Challenges

- Tighter Specifications than Data Wireless
  - More overlap required
  - Site survey essential
- Pervasive Coverage
  - Including: Elevators, stairways, building walkways, campus grounds, parking garages
- Fast Roaming
  - Poor roaming performance may drop or impair active voice calls
- Quality of Service
  - Call quality impacted by jitter, delay, and signal quality

Wireless IP Phones

Wireless IP Phones
802.11a/b/g/n phones for mobile communications and integrated applications

Multimode Phones

Multimode Phones
Cellular phones with 802.11a/b/g/n capabilities. Typically smart phones that are capable of data applications

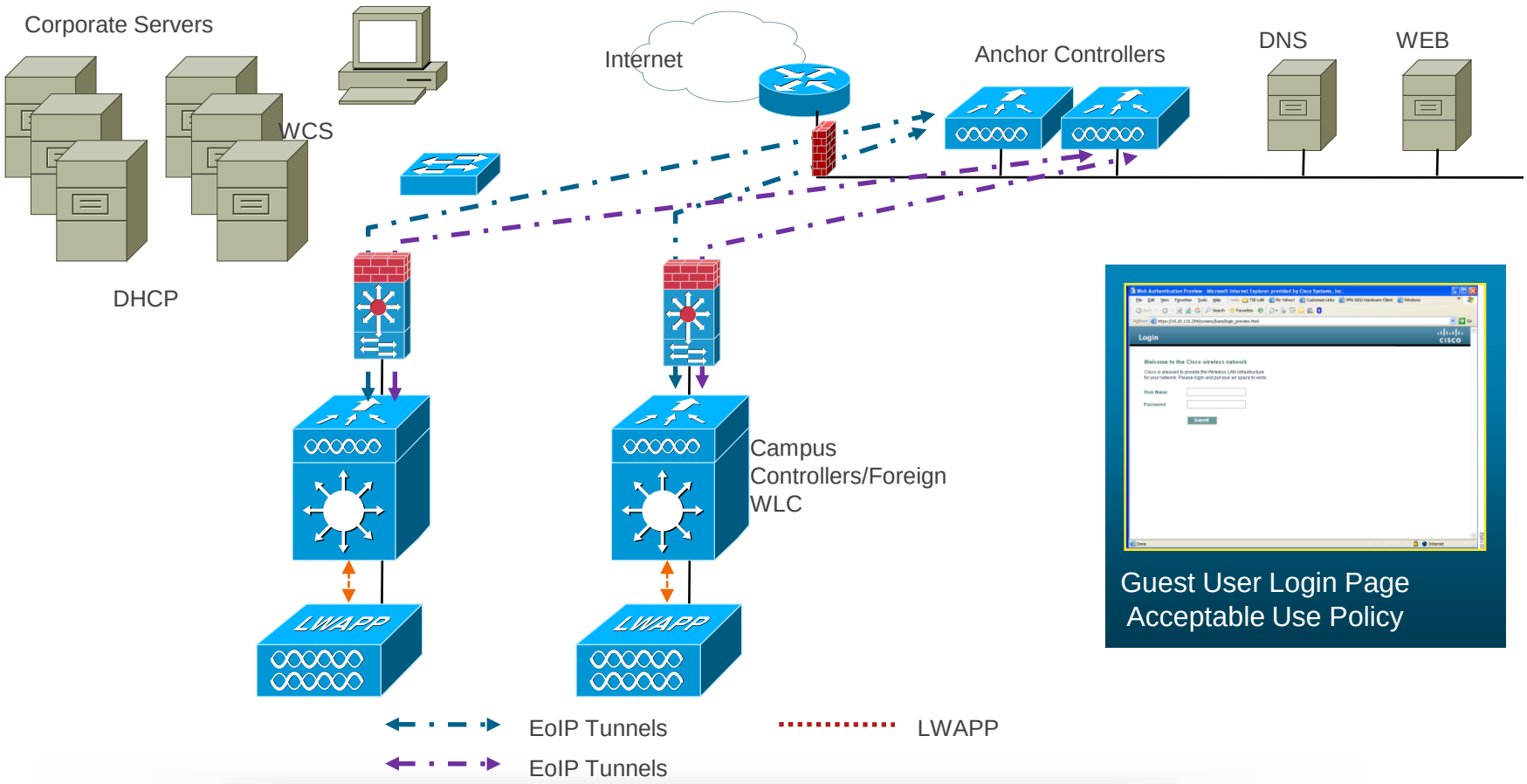
Laptops with Voice Clients

Laptops/PDAs with Voice Clients
These are primarily data devices with an application giving them voice call functionality. Applications run from Cisco Unified Personal Communicator to Skype or Fring

Voice over Wireless LAN

- Security Recommendations
  - Authentication—EAP-FAST
  - Key Management—WPA
  - Encryption—TKIP
  - Fast Roaming Protocol—CCKM
- AP Placement
  - AP Cell Boundary at -67dBm
  - AP Cell Overlap of 20%
  - Channel Separation of 19dB (CCA)

Guest Services—Wireless Architecture



Wireless Guest Services

- Provides patients and guests with wireless access to specific hospital “walled garden” resources or Internet
- Supports Login, Anonymous, and Acceptable Use Policy acceptance
- Can be provided by the hospital utilizing hospital’s Internet resources, or outsourced to a third-party wireless guest service provider utilizing existing WLAN infrastructure

Authentication and Access Control

- Who, when, where and how a group of individuals is allowed to use MGN services
- Cisco's Network Access Control and BioMedical NAC

Integration:

- Physical access control
- IP video surveillance
- Door lock controllers
- Badge or biomedical readers
- Alarm controllers

→ Smart+Connected Control System