2023 CCE Written Exam Review Webinar Series

August 9, 2023, through October 11, 2023

Session #7 IT/Telecommunications (IT Part 1)

September 20, 2023

Faculty: Ted Cohen, MS, CCE, FACCE
tedcohen@pacbell.net

About the host/moderator

Ishtar Al-Tahir

Ishtar Al-Tahir is a Clinical Engineer working towards her Professional Engineering Certification (PEng.) at the Children's Hospital of Eastern Ontario (CHEO). She joined CHEO in the fall of 2022, however her Clinical Engineering career began at Service New Brunswick in early 2021. She has a Masters in Science in Electrical Engineering (MSc.EE) from the University of New Brunswick, where she defended her biomedical engineering research thesis at the Institute of Biomedical Engineering on myoelectric controlled prosthesis.

In her spare time, she enjoys reading, cooking, playing ultimate frisbee, and learning as much as possible about Clinical Engineering. She volunteers her time with the ACCE, the Clinical Engineering Society of Ontario, and is the publicity co-chair of the CMBEC46 conference. Her passions also lie with promoting engineering and STEM fields to women and youth. She always looks forward to meeting new people, especially if they show her pictures of their dog.

Logistics

❖**All attendees have their microphones muted during the presentation.**

❖**Questions to the panelists must be submitted via the "Q&A" feature in Zoom at any time. They will be addressed at the Q&A portion.**

❖**If there is any urgent issue, please use the "chat" feature to communicate with the panelists/host.**

❖**Please remember to complete the webinar evaluation after attending. A link will be provided at the end.**

About the faculty

Ted Cohen, MS, CCE, FACCE
Clinical Engineering Consultant

- Part-time clinical engineering consultant. Projects include assisting VA HTM staff in VISN20 (Pacific Northwest) connect medical devices to the new VA Cerner EHR.
- For more than 35 years Manager of Clinical Engineering (now retired) at UC Davis Health in Sacramento CA, responsible for medical technology planning, and management of medical equipment installation, repair and maintenance services.
- Adjunct Professor (mostly retired), Electronics Technology, American River College. Developed a new BMET education program for a local community college district and co-taught some of its courses.
- Author of AAMI's Computerized Maintenance Management Systems for Clinical Engineering/HTM.
- Author of several CE articles and presentations on CMMS, benchmarking medical equipment services, and the integration of information technology and medical systems.
- Co-editor of ACCE News

Agenda/Learning Objectives

Information Technology 1 (September 20)

- Introduction to Medical Device Interoperability and Device Integration
- Clinical Systems Networking and Networking 101
- Integration of Medical Device Data with HL-7

Information Technology 2 (September 27)

- HL-7 continued
- DICOM
- Cybersecurity
- Confidentiality/HIPAA
- IT Service Management
- IT Other

Introduction to

Medical Device Interoperability and

Device Integration

Why is interoperability important to the clinical staff and patient care?

- Information for the **next clinical decision**

- Importance of clinical staff **workflow** optimization

- David Feinberg, CEO of Cerner:
  - " … streamlining the data needed from patients
  - " … reducing the documentation burden of caregivers
  - "… make it easier to get the right information to the right people at the right time."

- Other: Medical/legal/regulatory/confidentiality/security

Introduction: Medical device interoperability

Definition: “Functional medical device interoperability”: The ability for clinical medical devices to communicate in a consistent, predictable and reliable way, allowing for the exchange of, and interaction with, data from other medical devices and with patient data sources and repositories, such as electronic health records (EHRs), in order to enhance device and system functionality.

Reference: The Value of Medical Device Interoperability, westhealth.org, March 2013

Benefits from interoperability

Quality improvement: Safety interlocks reduce adverse events ($2 billion)

Reduced cost by avoidance of redundant testing ($3 billion)

Increased clinician productivity: Decreased time spent entering information ($12 billion)

Shorten length of stay increasing capacity ($18 billion)

Reference: The Value of Medical Device Interoperability, westhealth.org, March 2013

Example: Efficiency impact of monitor integration

Dept.	Beds	Occupancy Rate	No. Patients per Day	Avg. No. of Vitals Taken (Every *x* Minutes)	Avg No. of Vital Sign Variables per Reading	Estimated Time Savings per Day in Minutes*	Estimated Time Savings per Year in Hours	Estimated Time Savings at 70% Utilization
Adult ICU's	**66**	**98%**	**64.7**	**60**	**8**	**828**	**5,036**	**3,525**
PICU	**20**	**87%**	**17.4**	**60**	**8**	**223**	**1,355**	**948**
NICU	**52**	**70%**	**36.4**	**60**	**4**	**233**	**1,417**	**992**
Total	**138**		**118.5**			**1,284**	**7,808**	**5,466 Hrs/Yr**

*Based on typical time savings of 16 seconds per set of 4 vital signs entries

* Derived from a presentation at EPIC UGM, Cohen, Green et al, UCDHS, September 2009

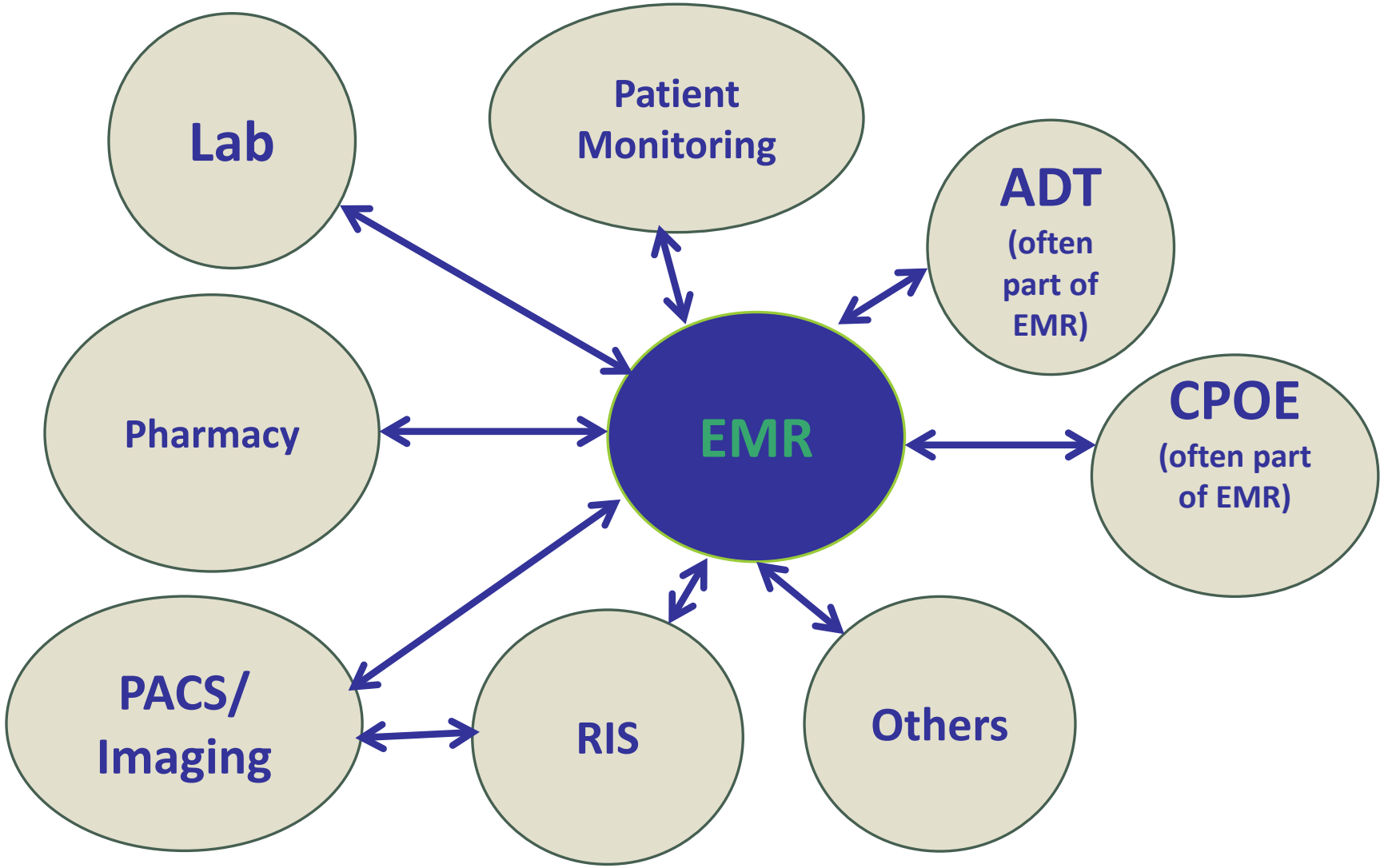
Typical interoperability tasks

Communicate information from one device/system to another

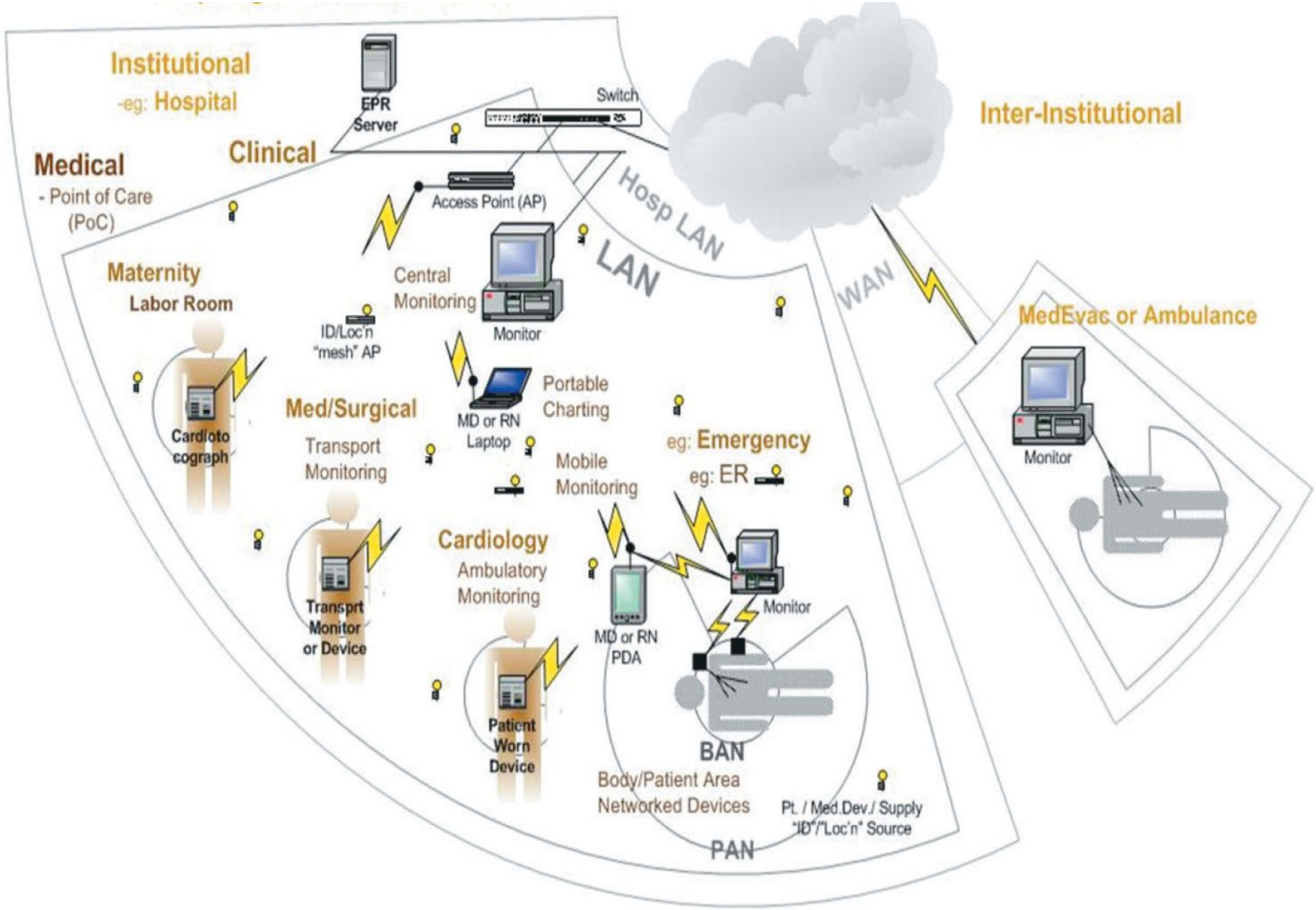
Display information – graphically and numerically

Transform information (i.e., convert data into a standard format recognized by other systems (e.g., EHR (Electronic Health Record))

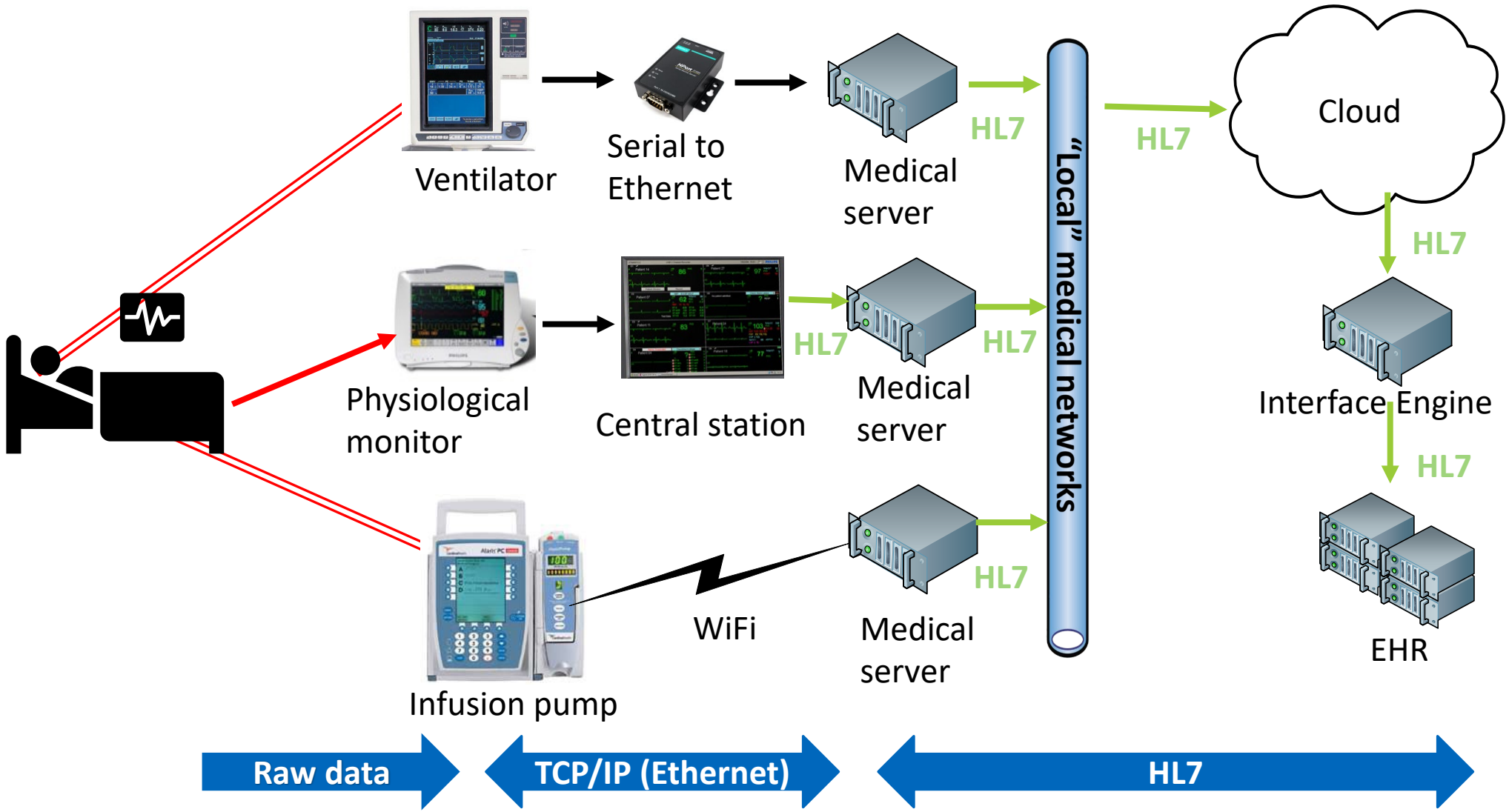
IT systems in healthcare facilities



Variety of locations



Example: Various medical device communication technologies

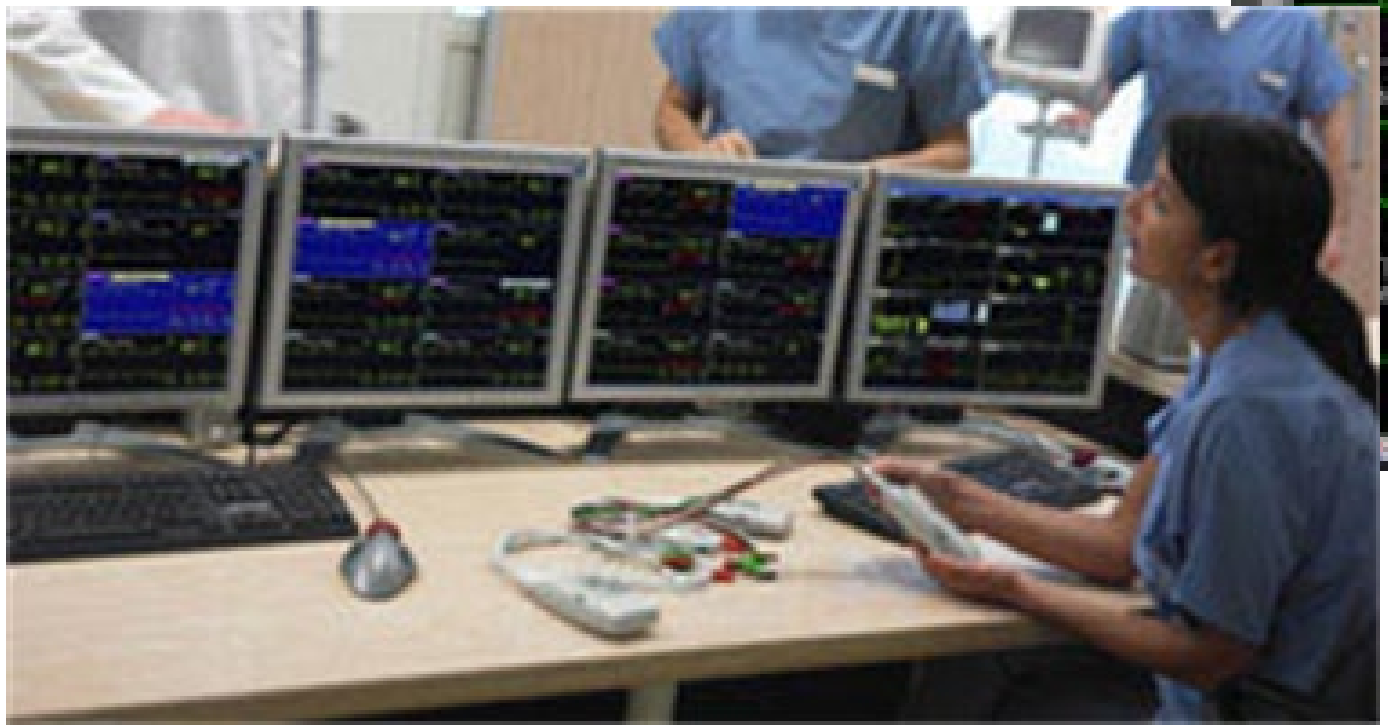


Bedside monitors

Example monitor parameter list

Commonly monitored parameters	Typical data format
Electrocardiogram (ECG)	Heart rate numeric, ECG waveform
Pulse oximetry (SpO_2)	Hemoglobin O_2 saturation numeric, plethysmogram waveform
Noninvasive blood pressure (NIBP)	Systolic/mean/diastolic BP numeric
Invasive blood pressure (IBP)	Waveform, systolic/mean/ diastolic BP numeric
Respiratory rate	Respiratory waveform, rate numeric
Temperature	Numeric
End-tidal carbon dioxide ($EtCO_2$)	CO_2 concentration numeric, capnogram waveform
Anesthetic agent	Agent concentration numeric
Cardiac output	Numerics for cardiac output, other hemodynamic calculations
Level of consciousness (e.g., bispectral index)	Numerical index†
Electroencephalogram (EEG)	Waveform
Fractional inspired oxygen (FiO_2)	O_2 concentration numeric and waveform
Mixed venous oxygen saturation (SvO_2)	Hemoglobin O_2 saturation numeric, plethysmogram waveform
Intracranial pressure (ICP)	Pressure waveform and numeric
Transcutaneous oxygen and carbon dioxide	Numerics for partial pressures of O_2 and CO_2

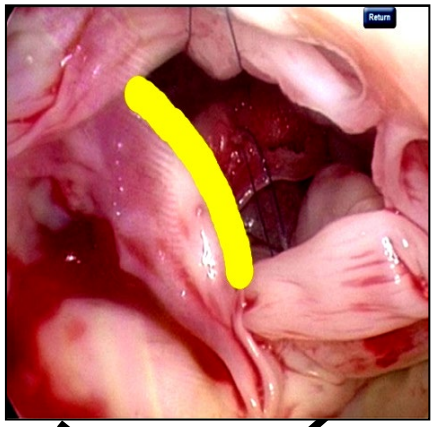
Central station monitors

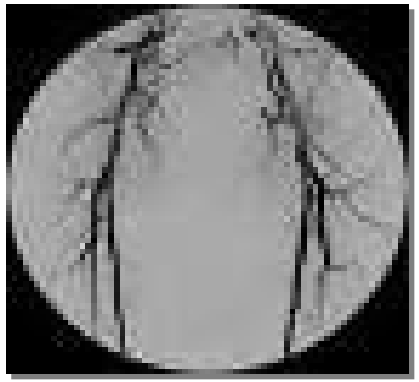


Infusion pumps

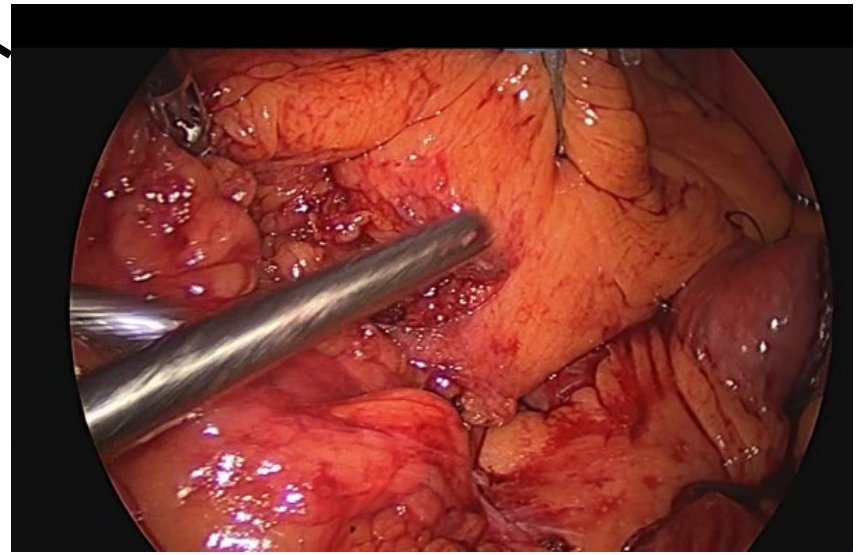
Ventilators

Charting and Imaging in the O.R.

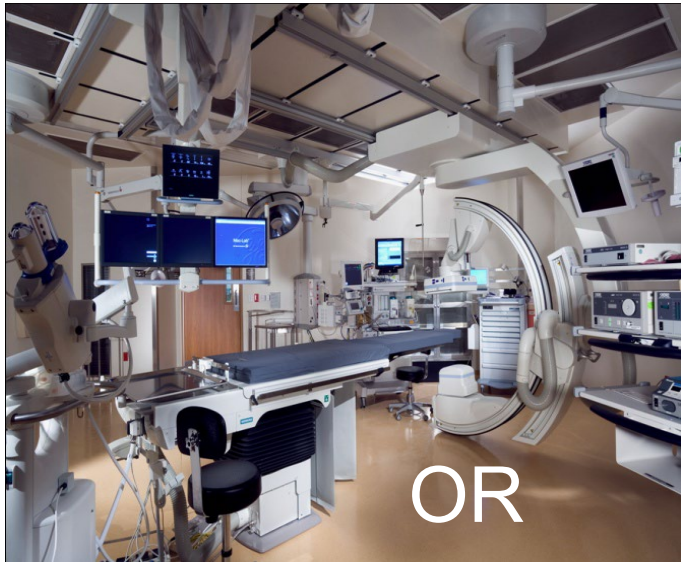


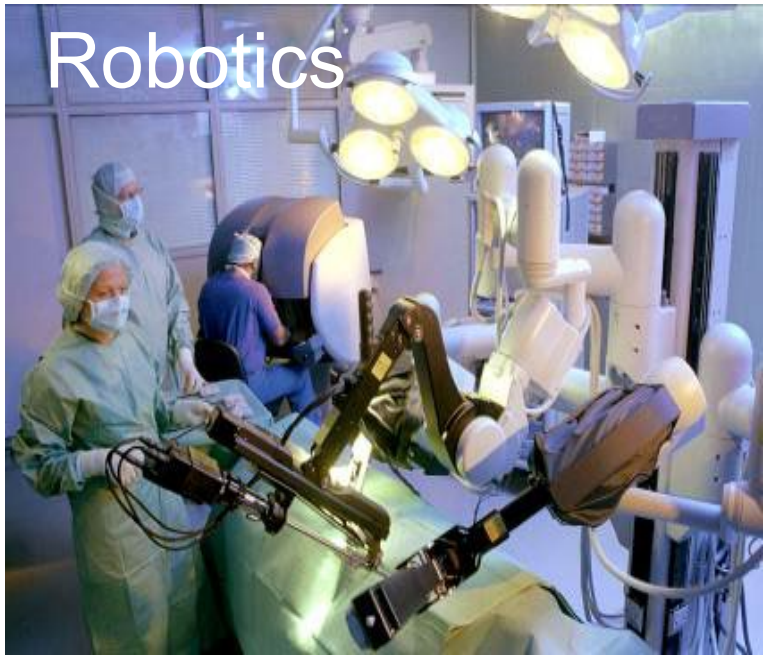


	01/24/04 00:00	01/23/04 00:00	01/22/04 00:00	01/2 00:
Glucose	115	120	140	
		120	110	
			108	
Glucose			137	
Glucose				
Glucose				
Hematocrit	40	39	40	
Hemoglobin	13.5	13.1	13.7	
LIPASE			45	
Platelet count			435	
Potassium			3.9	
Protime Secs	21.5	12.1	12.5	
	21	13.3	12.3	
		16.5	13	



Operating room video integration



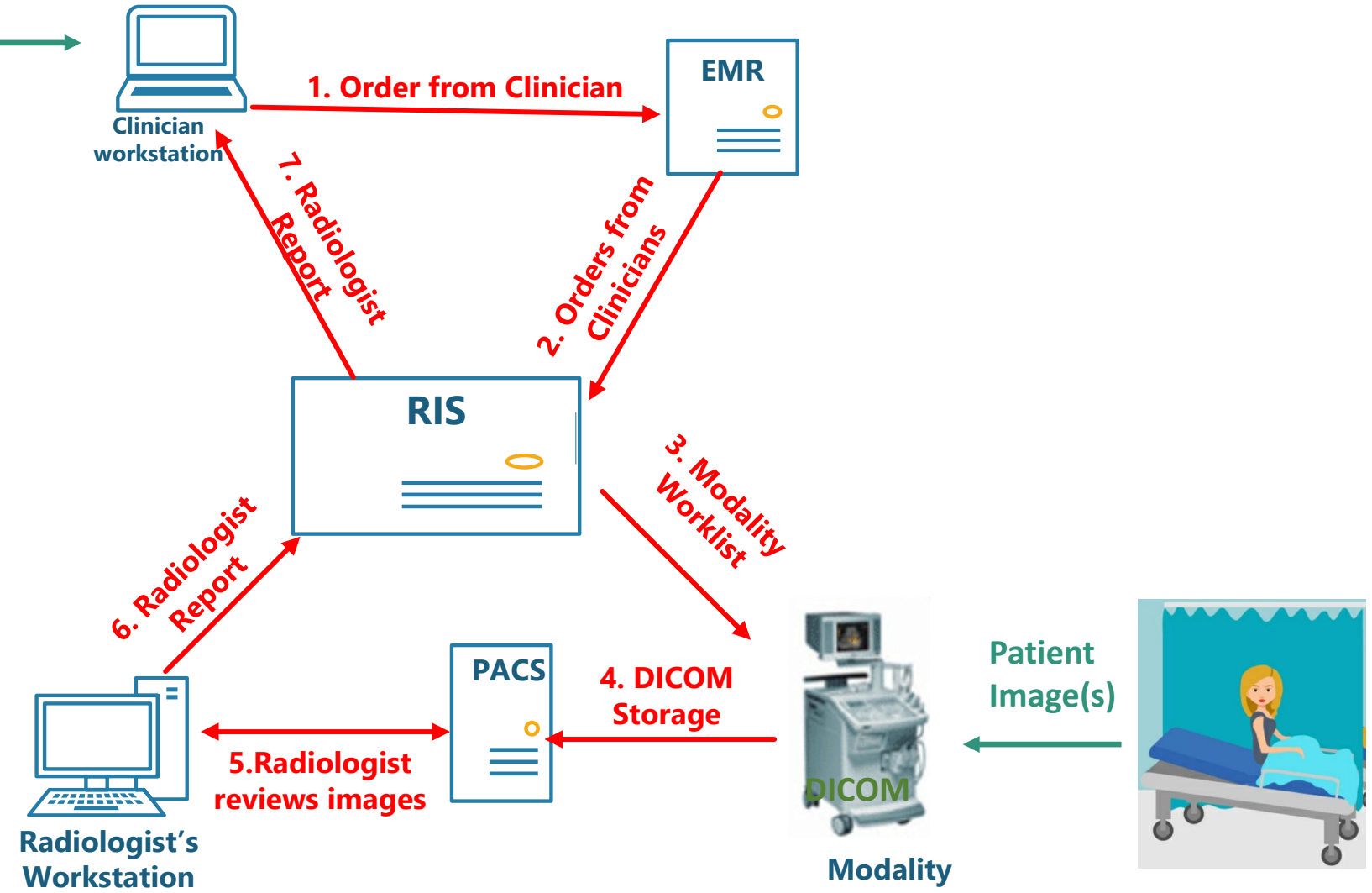


Wireless telemetry

Wireless wearable patient monitor (WMTS or 802.11)

ECG waveform display, pulse-ox, alarm capabilities in a patient-wearable device

Workflow example: Simplified RIS/PACS Data Flow



CEs need to understand clinical workflow

Artificial Intelligence/Augmented Intelligence (AI) and HTM

- We will use the term “Augmented Intelligence”
- Augmented Intelligence (AI) uses algorithms that integrate human intelligence and **machine-derived outputs** to improve health.
- Augmented intelligence focuses on an assistive role, emphasizing that its design enhances human intelligence rather than replaces it.

Radiology
- Image display/segmentation
- Diagnosis of specific pathology
- Positioning/placement

Cardiology
- ECG analysis
- Vital signs via camera feed
- Hemodynamics analysis

Hematology
- Sample quality analysis
- Clinical laboratory analyzers

Neurology
- Surgical guidance
- EEG analysis
- Myoelectric prosthesis control

EHR apps (nonregulated)
- Scoring and stratification for sepsis, decline

HTM activities (nonregulated)
- Predictive maintenance based on sensor readings
- Patterns in maintenance and repair data

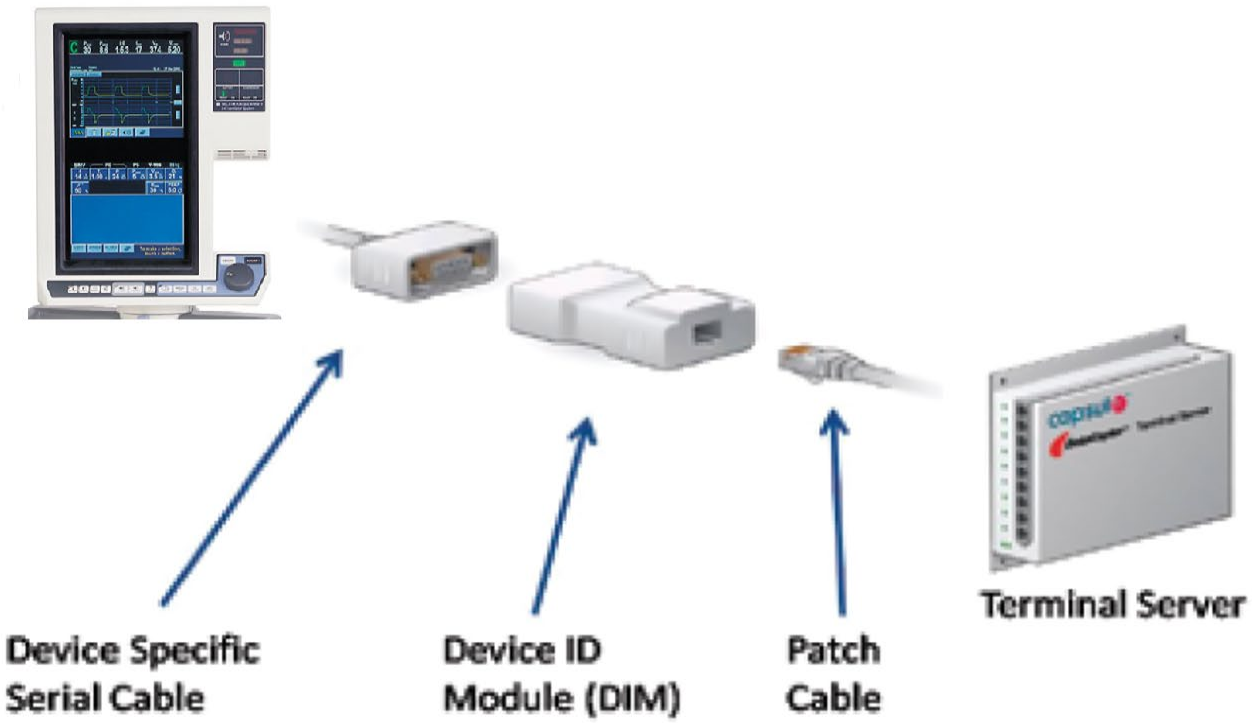
Additional considerations for device integration planning

- High-level clinical, administrative and financial support
- IT network readiness
- IT department readiness (e.g., EMR team, integration team, network team)
- EHR readiness
- Device readiness (e.g., which products, up to date versions)
- CE readiness
- Clinical staff readiness (e.g., training, comfort level with EMR)

CCE Review Course:

Clinical Systems Networking and Networking 101

First you have to get the device on the network: e.g., RS-232 Serial to TCP/IP



E.2 RS-232 port

The RS-232 serial ports are 9-pin male connectors configured as data terminal equipment (DTE). Figure E-3 shows the serial port pinout.

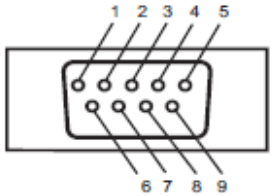


Figure E-3. RS-232 serial port pinout

Pin	Signal
1	Not connected
2	Receive data (RxD)
3	Transmit data (TxD)
4	Data terminal ready (DTR), terminated high
5	Ground (GND)
6	Not connected
7	Request to send (RTS)
8	Clear to send (CTS)
9	Not connected

Networking protocols

Multiple standards-based protocols (e.g., TCP, UDP, HTTP, FTP)

Used across many Operating Systems (e.g., Windows, Apple, Linux).

Multiple protocols bundled with each operating system allow communication to other networked computers and the Internet.

Most popular is TCP bundled with IP, called TCP/IP

TCP/IP (Transmission Control Protocol/Internet Protocol)

Protocol for the Internet

Available on almost all platforms and operating systems

Uses flexible addressing scheme that is routable on any size network

A large number of utilities and tools available

TCP/IP Communication

Each configuration has the following parts:

- IP address (Network Number and Host Number).
- Subnet Mask
- Gateway

IP address

32 bit number grouped into four groups of eight bits typically represented in dotted decimal:

- 11000000.10101000.00000000.00000001
- 192.168.0.1

Must be unique for each host (device) on the subnet

Has two parts, network and host as determined by subnet mask

Private IP addresses

Private IP addresses are only used locally, NOT routed on the internet:

- Class A: 10.x.x.x
- Class B: 172.16.x.x – 172.31.x.x
- Class C: 192.168.x.x

IP address, Subnet mask

Subnet mask determines the network boundaries, or which part of the IP address is the network/subnet and which is the host/computer/device:

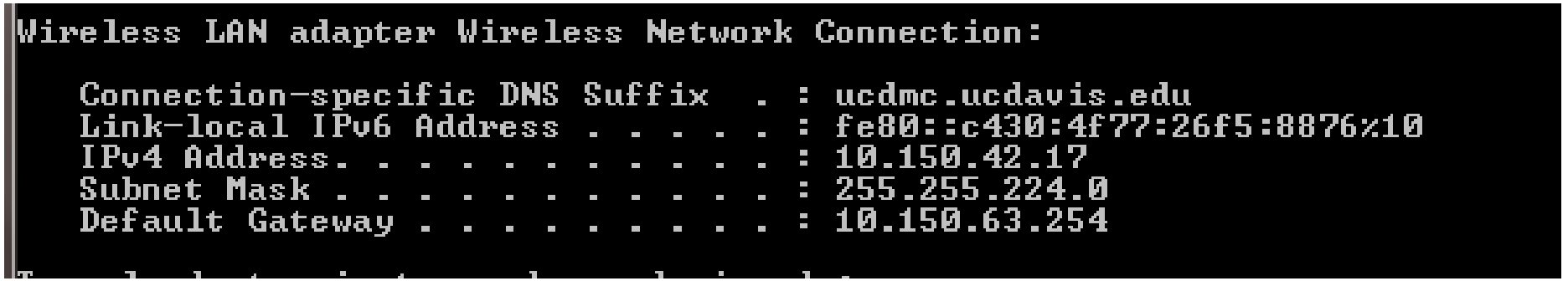
- In binary, the non-zero numbers in the mask refer to the network
- Zeros in the mask are the part of the IP address that contains the host/device addresses.

IP addressing, valid subnet masks:

- Has to start with 1 in the leftmost digit in binary value
- All the digits with ones have to be contiguous

Subnet Mask	Binary Value of 2 rightmost octets	# Addresses	# Hosts	CIDR Notation
255.255.255.252	11111111 11111100	4	2	/30
255.255.255.248	11111111 11111000	8	6	/29
255.255.255.240	11111111 11110000	16	14	/28
255.255.255.224	11111111 11100000	32	30	/27
255.255.255.192	11111111 11000000	64	62	/26
255.255.255.128	11111111 10000000	128	126	/25
255.255.255.0	11111111 00000000	**256**	**254**	**/24**
255.255.254.0	11111110 00000000	512	510	/23
255.255.252.0	11111100 00000000	1024	1022	/22
255.255.248.0	11111000 00000000	2048	2046	/21
255.255.240.0	11110000 00000000	4096	4094	/20
255.255.224.0	11100000 00000000	8192	8190	/19
255.255.192.0	11000000 00000000	16384	16382	/18
255.255.128.0	10000000 00000000	32768	32766	/17
255.255.0.0	00000000 00000000	65536	65534	/16

Example from UC Davis Guest Network



Example from UCDMC Guest network:

IP: 10.150.42.17

Subnet Mask: 255.255.224.0

- How many host devices can this guest network support?

Assigning IP addresses

Two different ways to assign IP addresses:

- Static (aka Manual): IT administrator assigns “Static” IP address
- DHCP: DHCP server assigns IP address

Two basic ways for DHCP server to assign IP addresses:

- Dynamic: DHCP Server leases a unique IP address to the client (or device) for a specified period of time. Next time same device could get a different address.
- Reserved: DHCP Server permanently assigns a unique IP address to client (or device) based on device’s MAC address

Routing

Switch:

- Multi-port repeater
- Connects server to hosts (i.e., computers, medical devices)
- Broadcasts incoming signal to connected hosts
- Learns address of each host based on incoming packets
- Routes packets to destination only
- Minimizes traffic and collisions

Routing

Router:

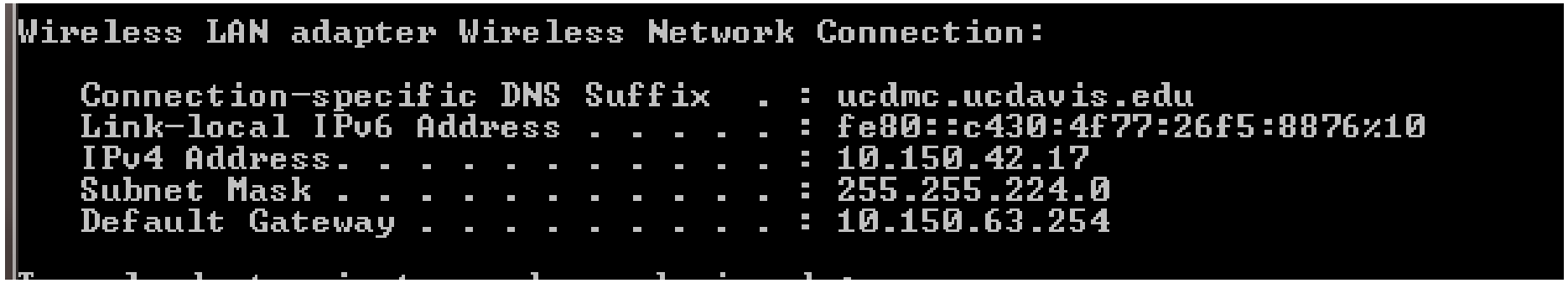
- Connects multiple networks with same protocol
- Networks can be in different locations (Internet)
- Multiple routers can be used on the same network
- Learns the path to destination address to route packets to destination only
- Forwards packets to next “Hop” or gateway if full path not known.

Routing

Gateway:

- Connects multiple networks regardless of protocol
- Can be a stand-alone router or computer or part of an existing host/server/network
- The “Go-To” device if IP address is not in the local router table

Example from UC Davis Guest Network



Example from UCDMC Guest network:

IP: 10.150.42.17

Subnet Mask: 255.255.224.0

Default Gateway: 10.150.63.254

The OSI, "7 Layer", Reference Model

Group	#	Layer Name	Key Responsibilities	Data Type Handled	Scope
Lower Layers	1	Physical	Encoding and Signaling; Physical Data Transmission; Hardware Specifications; Topology and Design	Bits	Electrical or light signals sent between local devices
	2	Data Link	Logical Link Control; Media Access Control; Data Framing; Addressing; Error Detection and Handling; Defining Requirements of Physical Layer	Frames	Low-level data messages between local devices
	3	Network	Logical Addressing; Routing; Datagram Encapsulation; Fragmentation and Reassembly; Error Handling and Diagnostics	Datagrams / Packets	Messages between local or remote devices
	4	Transport	Process-Level Addressing; Multiplexing/Demultiplexing; Connections; Segmentation and Reassembly; Acknowledgments and Retransmissions; Flow Control	Datagrams / Segments	Communication between software processes

1. Physical wiring, ethernet

2. MAC address, IP, switches, broadcast

3. IP addressing, router protocols

4. TCP, UDP, flow control

The OSI "7 Layer" Reference Model

5	**Session**	Session Establishment, Management and Termination	Sessions	Sessions between local or remote devices
6	**Presentation**	Data Translation; Compression and Encryption	Encoded User Data	Application data representations
7	**Application**	User Application Services	User Data	Application data

5. Flow control, half/full duplex

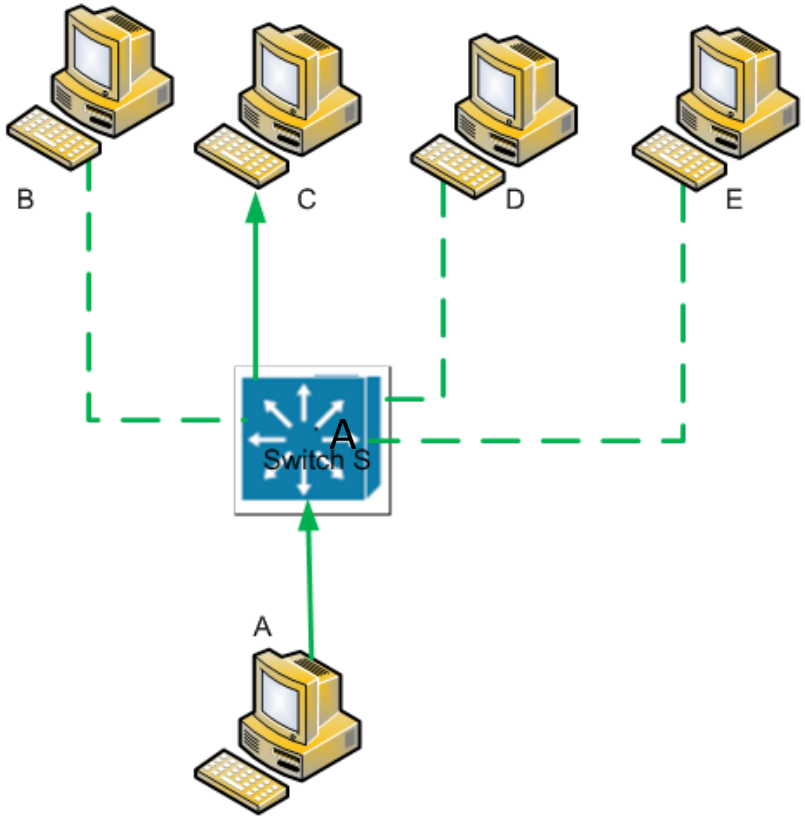
6.(en)(de)cryption, compression (JPEG, MPEG

7. e-mail, web, FTP

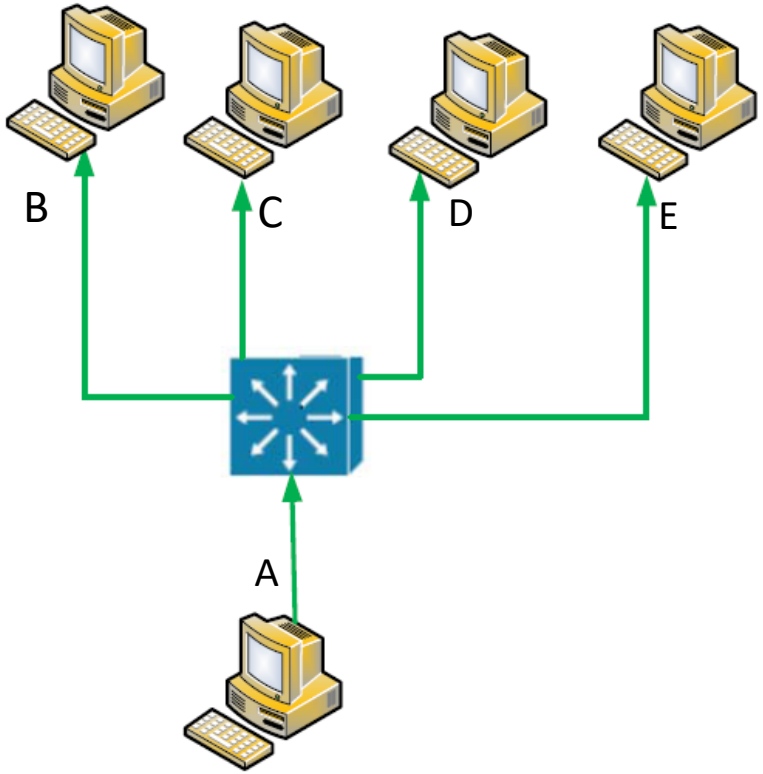
TCP and UDP

- TCP (Transmission Control Protocol)
  - Packet-oriented communication service
  - Optimized for accuracy and reliability, rather than timely delivery
- UDP (User Datagram Protocol)
  - Message oriented communication service
  - Less overhead than TCP
  - More timely than TCP, less reliable than TCP (may drop packets rather than delay packets)

Unicast and Broadcast on a Local Area Network (LAN)



Unicast: One to One

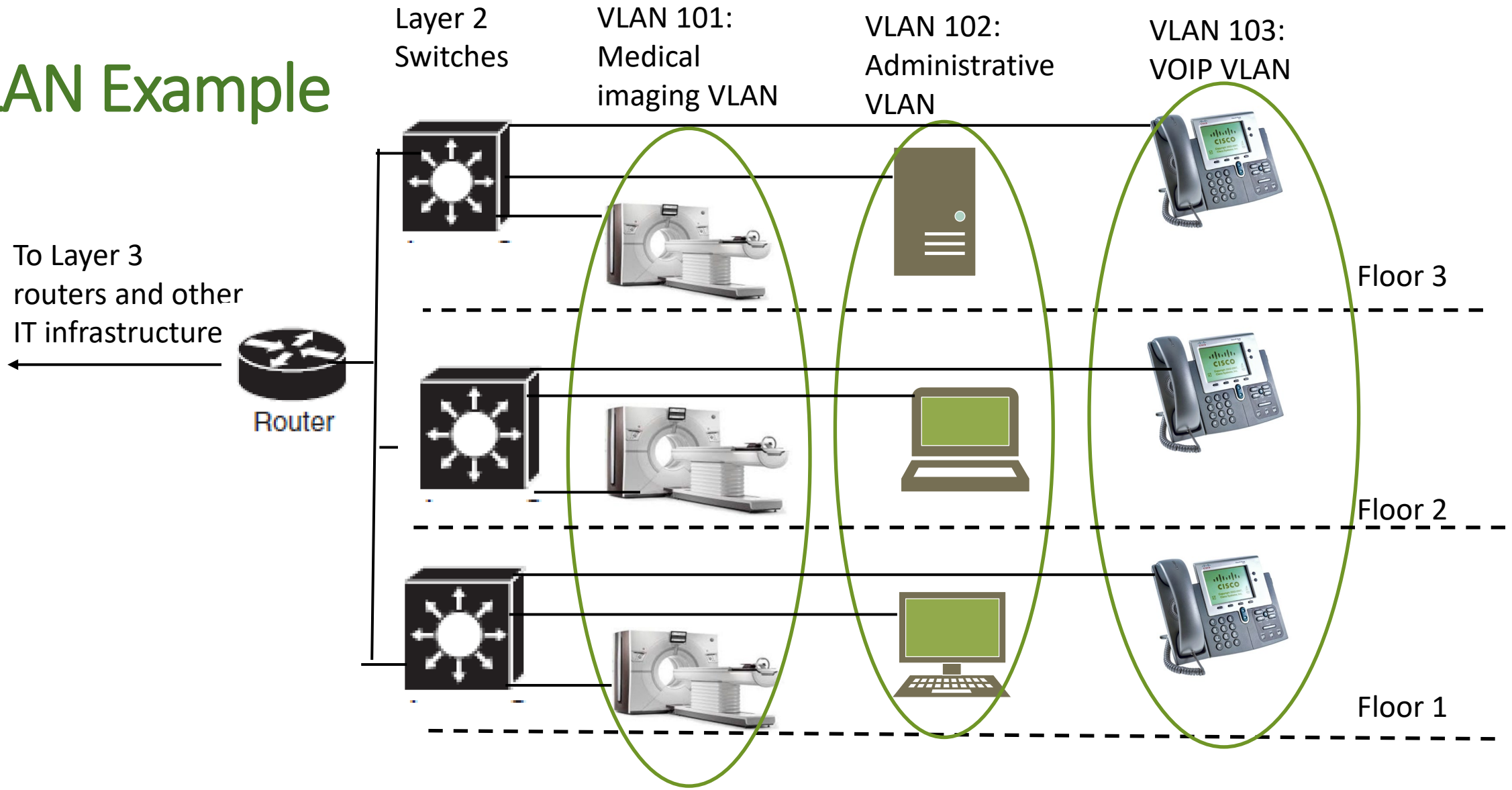


Broadcast: One to All on same subset

VLAN (Virtual Local Area Network)

- A group of devices on one or more local area networks that are configured to communicate as if they were attached to the same switch.
- VLANs allow network administrators to group devices together even if the devices are not directly connected to the same network switch.
- VLANs are based on logical instead of physical connections
- VLANs define broadcast domains in a Layer 2 network.
- **Broadcast domain** is the set of all devices that will receive broadcast messages originating from any device within the VLAN.
- Layer 2 switches create broadcast domains based on the configuration of the switch.

VLAN Example



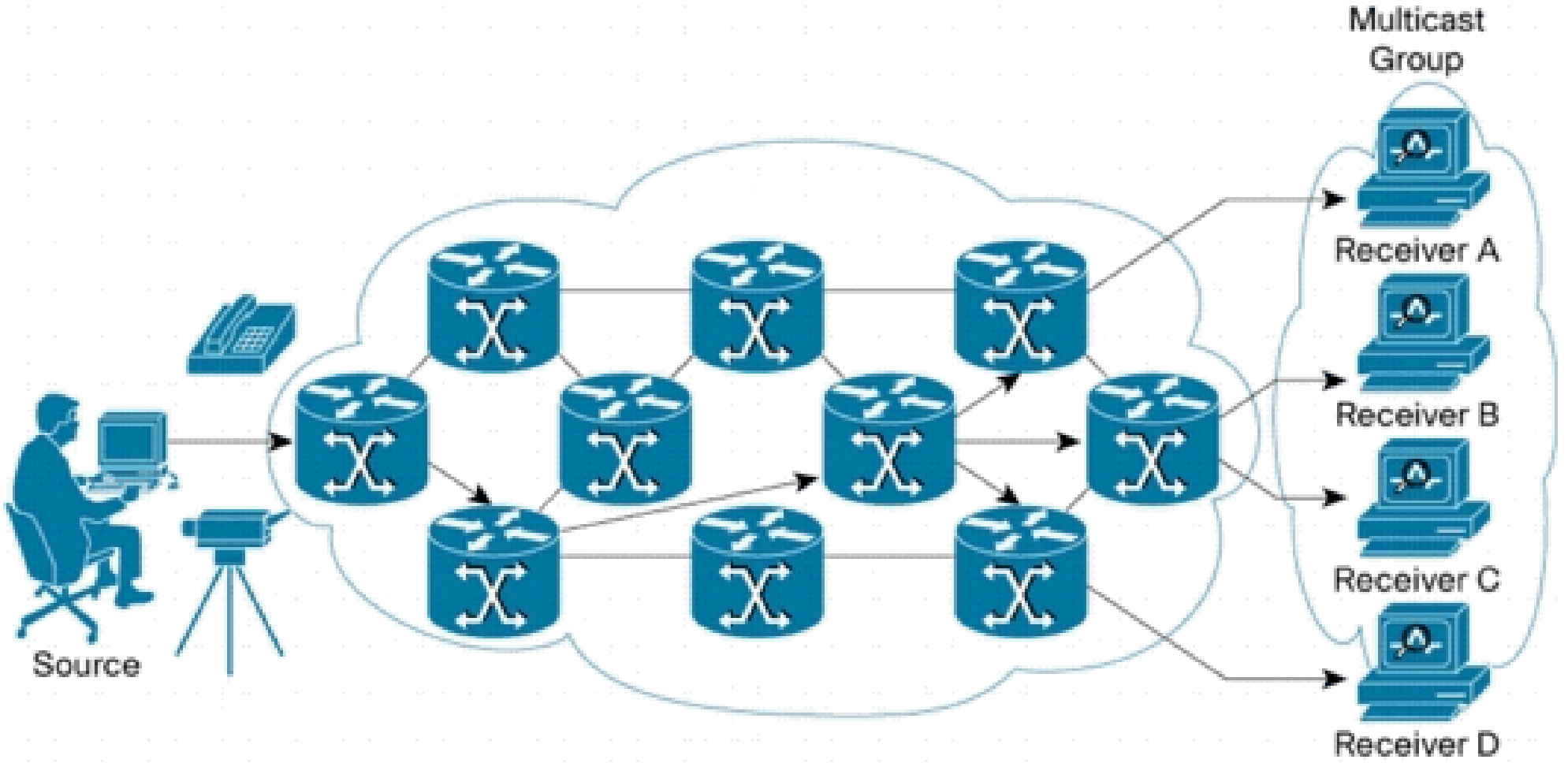
IP Multicast

Simultaneously delivers a single stream of data to several recipients conserving bandwidth and reducing traffic for high bandwidth applications (e.g. MPEG video)

Also, conserves bandwidth for low bandwidth applications with high number of recipients

Typically uses UDP

Multicast



Multicast: One to many (defined group)

Network Ports, TCP examples

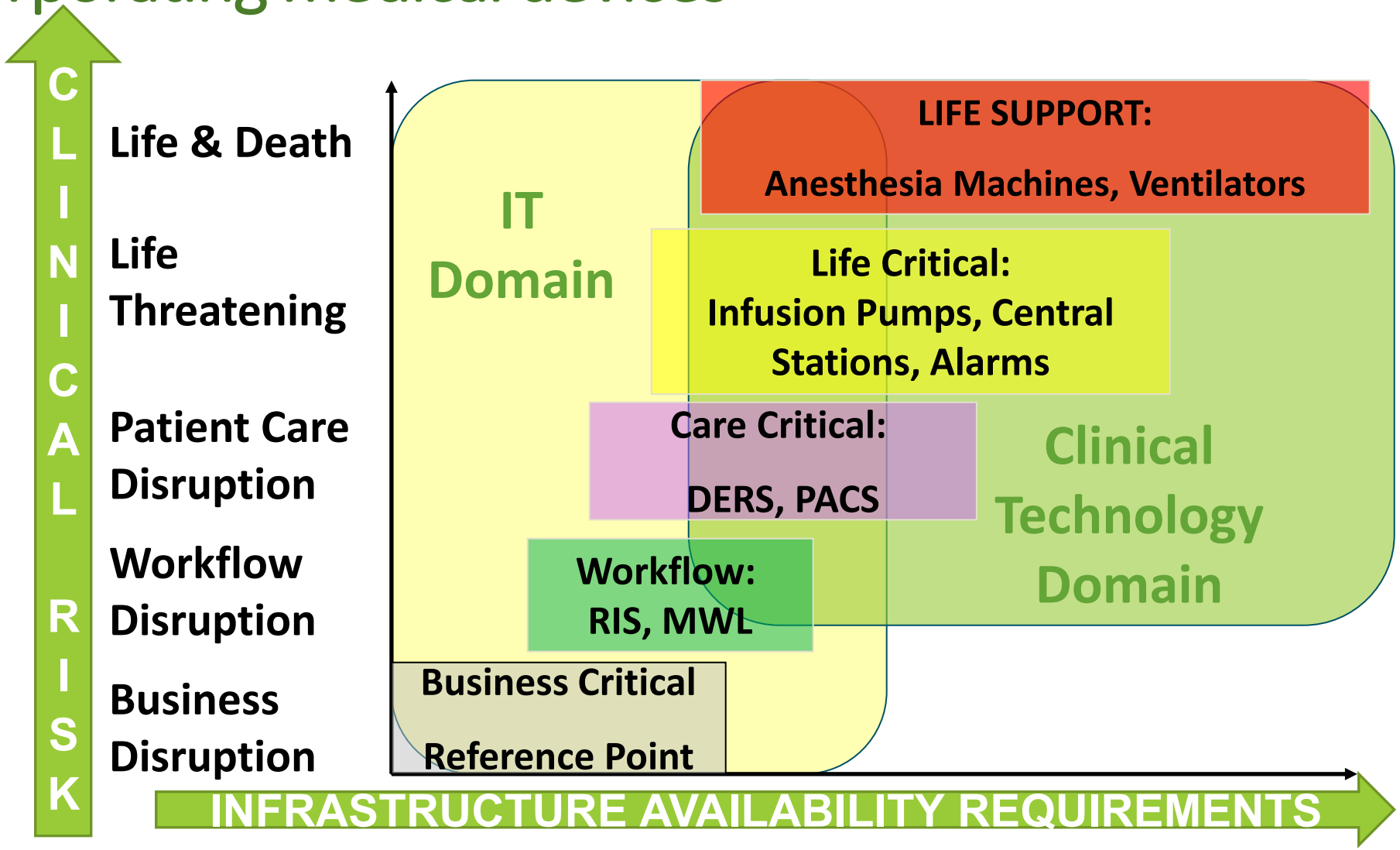
Port #	Port Description
20	FTP: File transfer
22	SSH: Secure shell
23	Telnet
25	SMTP (Mail)
53	DNS: Name Service
67	DHCP (UDP): IP Address
80	HTTP: Internet Communication
104	DICOM
123	Network Time (NTP)

Port #	Port Description
389	LDAP (Active Directory)
443	HTTPS: Secure internet communication
3389	RDP: Remote Desktop Protocol
1109	Kerberos
1719	H.323: AV communication
2575	HL-7
8080	HTTP: Internet Communication
17500	DropBox
41794	Crestron Control Panel

CCE Review Course:

IT Network Architecture for Medical Devices

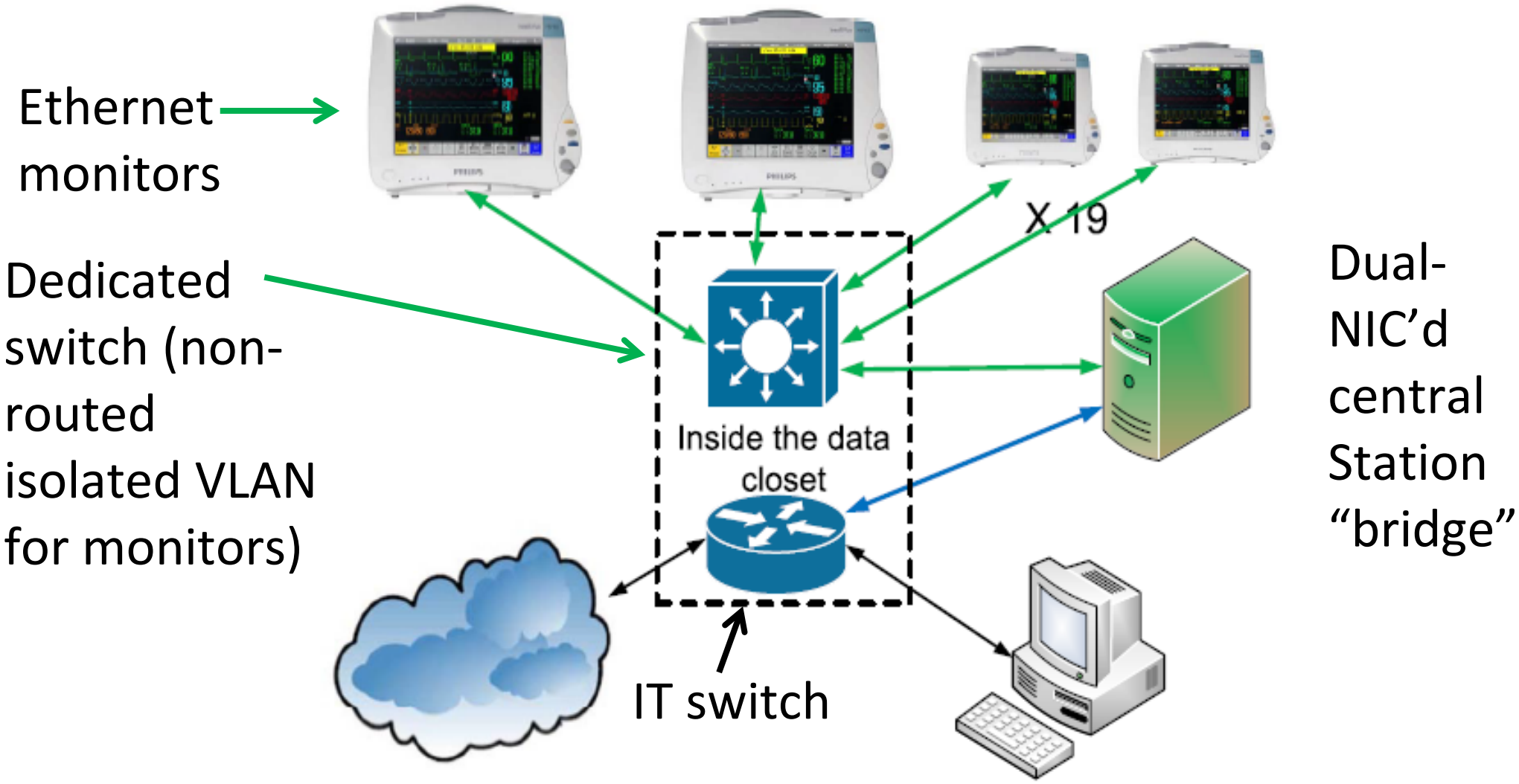
IEC 80001: Application of risk management for IT-networks incorporating medical devices



Network Architectures for Medical Devices

- Unique characteristics of networked medical devices (and some other "special" devices). (e.g., bandwidth and latency requirements, regulations)
- Private networks: Separate ports, cabling, switches and, sometimes routers, dedicated to medical devices. Often "bridged" to non-private network.
- One Physical Network: All networked equipment including medical devices are connected to a common physical infrastructure including wiring, switches, routers etc. Requires:
  - High speed network (minimize congestion)
  - Modern switches, routers that support QoS, and VRF (Virtual Routing and Forwarding) capability
  - Uses LOGICAL ISOLATION concept for segmenting the network

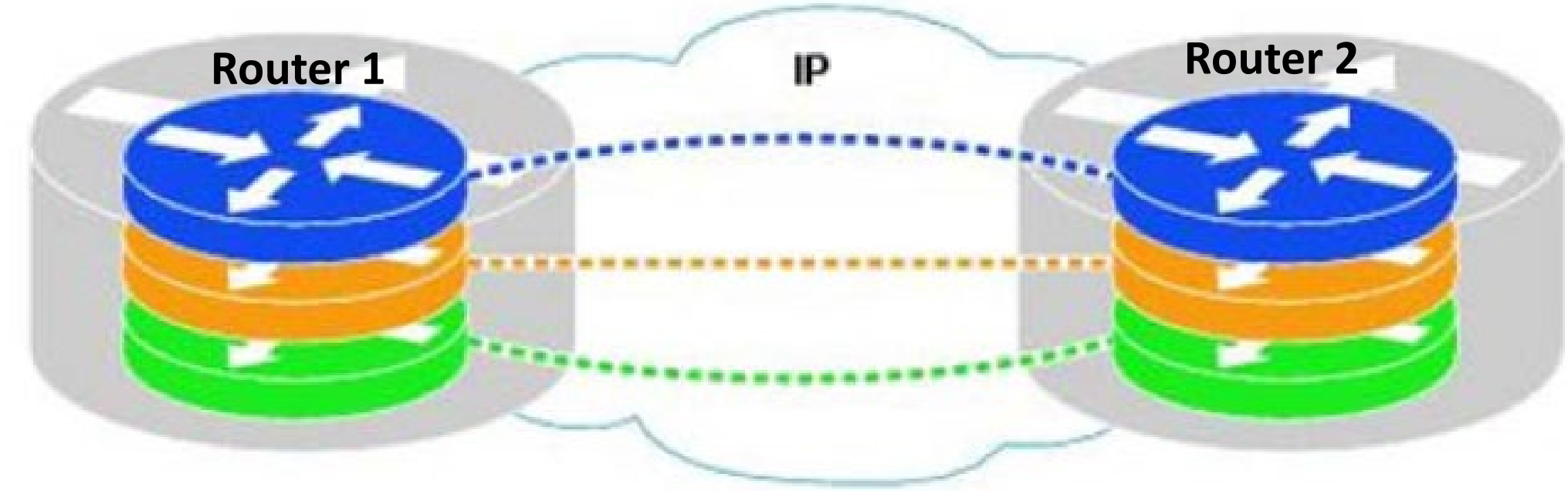
Example: Physically isolated network with bridge



Network Segmentation

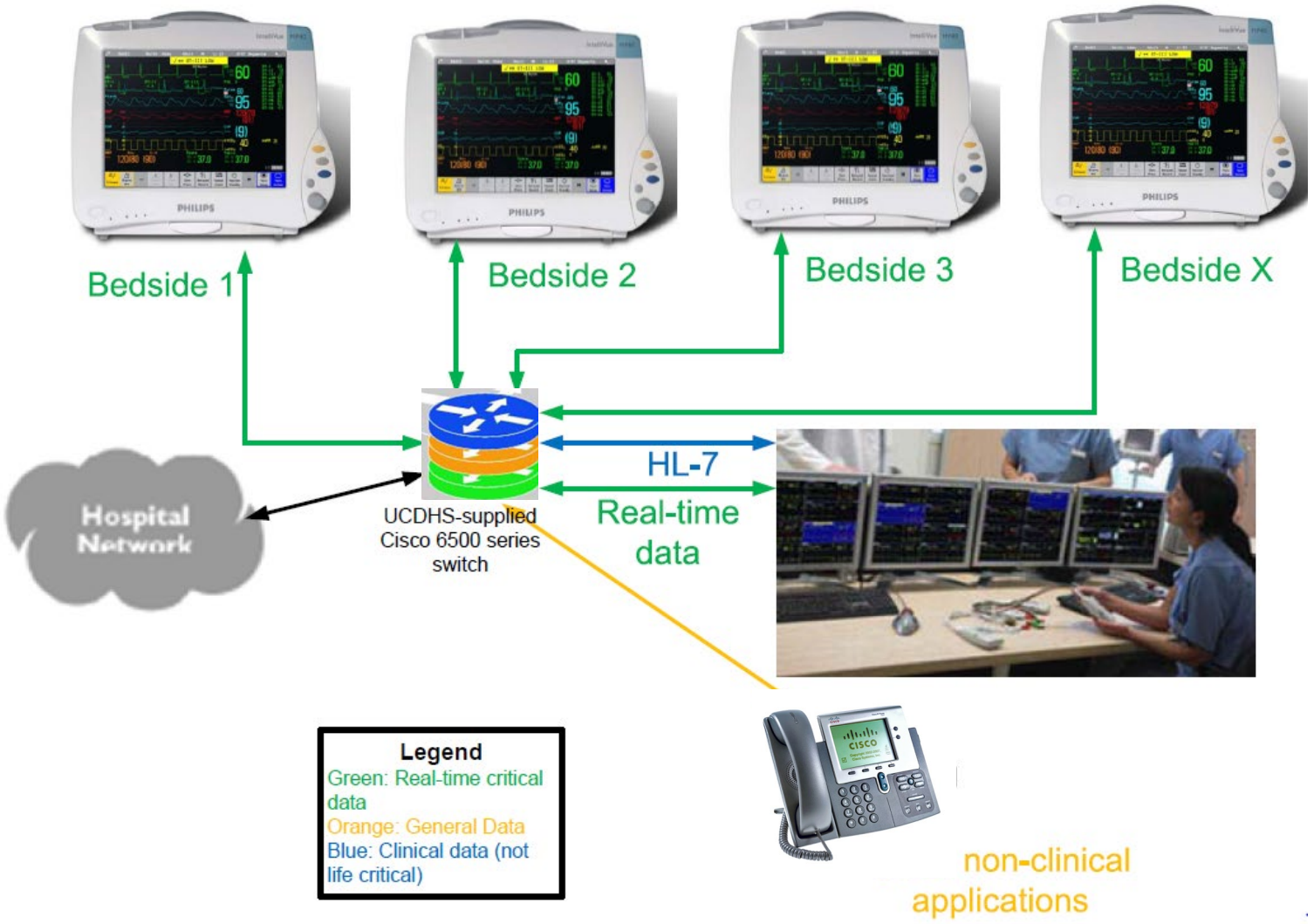
- Segmentation divides a computer network into smaller parts in order to improve network performance and security
- Types of segmentation:
  - VLANS
  - Firewalls
  - Access control lists
  - Virtual routing and forwarding (VRFs): Layer 3 “sets” of VLANs based on type of data traffic, types of end-users etc
  - Micro-segmentation: Data traffic is “tagged” and then network policies use that information to create granular segments.

Converged, segmented wired network



Enables one physical network to be sliced up into multiple logically isolated networks where each segment can be independently managed and programmed to meet a variety of network requirements. Example: Three segments: ***Green=Clinical, Blue=Admin, Gold=VOIP Phones.***

Converged network: Wired patient monitor example



Quality of Service example

UCDHS NetV2 QoS Classes	Priority (CoS)	Sample Signal Characteristics
Voice	5	VOIP, real-time voice, latency; jitter and loss sensitive
Life Critical (CLC)	5	Real-time clinical waveforms and alarms; latency, jitter and loss sensitive
Clinical Interactive Video	4	Real-time clinical video (and audio), high-bandwidth potential; latency, jitter and loss sensitive
General Interactive Video	4	Real-time video and audio, high-bandwidth potential, latency; jitter and loss sensitive
Streaming Video	4	Real-time stored video and audio , moderate bandwidth potential.
Clinical Data (CGP)	3	HL-7 clinical data . Delays impact user experience
DICOM (CGP)	3	DICOM images. Delays impact user experience
Best Effort	0	Everything else (internet, intranet etc)

CCE Review Course:

Wireless Networking

Advantages of wireless networking

Mobility!

- Fast access to data without being tethered to a desktop computer
- Mobile carts with computers used to document patient information data then transmitted back to central server for processing and storage
- VoIP provides fast access to personnel
- Vital signs monitors are incorporating 802.11 wireless for transmission during transport
- Wireless infusion pumps allowing upload of Drug Lirnaries and download of infusion data
- Real-Time location systems (RTLS) using RFID for inventory control
- And lots of other wireless applications

Wireless standards IEEE 802.11

- International standards for wireless networking
- 2.4GHz ISM band for 802.11b, 802.11g, 802.11n, 802.11ax
- 5 GHz ISM band for 802.11a, 802.11n, 802.11 ax, 802.11ac
- Medical device maximum throughput of up to 600 Mbps (802.11n)
- Indoor range varies a lot by building construction
- Ideal access point density every 1000 to 2000 square feet

IEEE 802.11 Wireless standards comparisons

Standard	Year Adapted	Frequency	Maximum Speed	Comments
802.11 (FH)	1997	2.4 GHZ	2 Mbps	Obsolete
802.11a	1999	5 GHZ	54 Mbps	Common use
802.11b	1999	2.4 GHZ	11 Mbps	Slow, poor security, heading toward obsolete
802.11g	2003	2.4 GHZ	54 Mbps	Common use
802.11n	2008	2.4, 5 GHZ	600 Mbps	
802.11ac	2014	5 GHZ	1300 Mbps	Newer, medical devices?
802.11ax	2019	2.4, 5, 60 GHZ	7 Gbps	Newest, medical devices?

802.11 SSIDs

- SSID: Name that identifies a specific 802.11 wireless “subnet”
- SSID stands for “Service Set Identifier”
- Increasing the number of SSIDs increases overhead, and therefore, decreases wireless performance
- Many medical device vendors require (or recommend) their own SSID, which often is an unrealistic expectation

Wireless challenges in healthcare

- 100% coverage in buildings of varying construction is difficult
- Wireless resources, such as bandwidth and number of SSIDs, need to be managed
- BYOD (visitors, patients and staff bring their own devices)
- Data security over wireless connections can be complex, but is mandatory
- Some other systems emit RF that can interfere with wireless network transmissions (e.g. Microwave ovens (intentional), ESUs (unintentional)

Wireless needs assessment

- Does application need to be wireless (i.e., mobile)?
- Capacity and coverage needs (including BYOD)
- Peak device density
- Peak people density
- Peak times
- Access points (A/Ps) need power (e.g., PoE (Power over Ethernet))
- Network switch and other IT infrastructure requirements
- Not as reliable for life-critical applications (e.g., alarms)

Medical device networking summary

- CEs need to identify medical device-based infrastructure requirements to IT Department
- Obtain vendor network requirements documents and help IT staff interpret them
- Life Critical versus Mission Critical
- Regulated versus non-regulated domain
- Summarize requirements based on functionality, not necessarily IT solutions (virtual isolation, segmentation)
- Requirements example: Low network latency for alarm notifications
- Know YOUR network (e.g., network diagram for medical device-relevant portion of network; wire and wireless)

CCE Review Course:

Integration of Medical Device Data: HL-7

HL7: What is HL7?

- HL7 is a common **language** that allows disparate systems to communicate with each other (e.g., UNIX/LINIX and Windows)
- HL7: An application layer (layer 7) protocol developed to provide a basic framework of encoding rules for building integrated healthcare IT systems
- HL7: An ANSI accredited Standards Developing Organization whose mission is to write consensus standards for healthcare IT interfaces
- HL7: https://www.hl7.org/

HL7: Overview

- Like any language, HL7 has its own grammar and syntax
- Version 2.x is in most common usage
- Version 2.31 has 12 chapters and 5 appendices (over 1500 pages long!)
- More than 80 message types
- More than 86 event types
- Hundreds of Different Fields
- More than 50 data types

HL7 Overview: Basic message structure

- **Segment**
  - An HL7 message consists of a group of segments in a defined sequence
  - Segments or groups of segments are optional, required, and/or repeatable.
- **Message Header**
  - Every HL7 message specifies MSH as its first segment
- **Message Type**
  - Defines the purpose for the message
  - A three-character code
  - Present in every HL7 message in the Message Header - MSH-9. (ninth field in the message header)
- **Trigger Event**
  - A real-world event that initiates communication and the sending of a message
  - Shown as part of the message type.

HL7 Overview: Message Types

- **Message Type**
  - Three-character code present in every HL7 message in MSH-9.
  - **Trigger event**: An HL7 trigger event is a real-world event that initiates communication and the sending of a message.
  - Both the message type and trigger event are found in the MSH-9 field
  - Each message type and trigger event within a specific HL7 version has a defined format. However, this format may vary between HL7 versions.
  - Examples:
    - **ADT-A01**: **ADT** (Admit/Discharge Transfer) is the message type, **A01 (Patient Admit)** is the trigger event.
    - **ADT-A04**: Outpatient Registration message
    - ADT is also sometimes called “Demographics”

HL7 Example Message Types

Message Type	Trigger	Syntax
Demographics (ADT)	Admit a patient (A01)	ADT^A01
Demographics (ADT)	Transfer a patient (A02)	ADT^A02
Demographics (ADT)	Discharge a patient (A03)	ADT^A03
Demographics (ADT)	Register a patient (A04)	ADT^A04
Orders (ORM)	Orderer sends an order (O01)	ORM^O01
Results (ORU)	Transmit order results, unsolicited (R01)	ORU^R01
Results (ORU)	Waveform results (W01)	ORU^W01
Charges (DFT)	Post financial transaction detail (P03)	DFT^P03

HL7 Overview: Segments

- HL7 segments: A group of fields that contain varying types of data. Each segment exists independently and can be utilized in multiple message types, in varying sequences

- Segments may be required for a particular message type, or optional
- A unique three-character code (i.e, “Segment ID”) identifies each segment.
- The most commonly utilized segments are shown in the table at the right
- There are more than 150 different HL7 segments defined

Segment Examples

Segment ID – Segment Description

DG1 – Diagnosis
EVN – Event type
FT1 – Financial transaction
GT1 – Guarantor
IN1 – Insurance
MSH – Message header
NK1 – Next of kin
NTE – Notes and comments
OBR – Observation request
OBX – Observation result
ORC – Common order
PID – Patient identification
PV1 – Patient visit information
NCK – System Clock

HL7 Overview: ADT (Patient Registration) Message Example

MSH|^~\&|EPIC|EPICADT|SMS|SMSADT|199912271408|CHARRIS|**ADT^A04**|1817457|D|2.5|

PID||0493575^^^2^ID1|454721||DOE^JOHN^^^^|DOE^JOHN^^^^|19480203|M||B|254MYSTREETAVE^^MYTOWN^OH^44123^USA||(216)1234567|||M|NON|400003403~1129086|

PV1||O|168~219~C~PMA^^^^^^^^^|||277^ALLENMYLASTNAME^BONNIE^^^^|||||||||||2688684|||||||||||||||||||||||199912271408|||||00237685 3

HL7 Overview: ADT (Patient Registration) Message Header

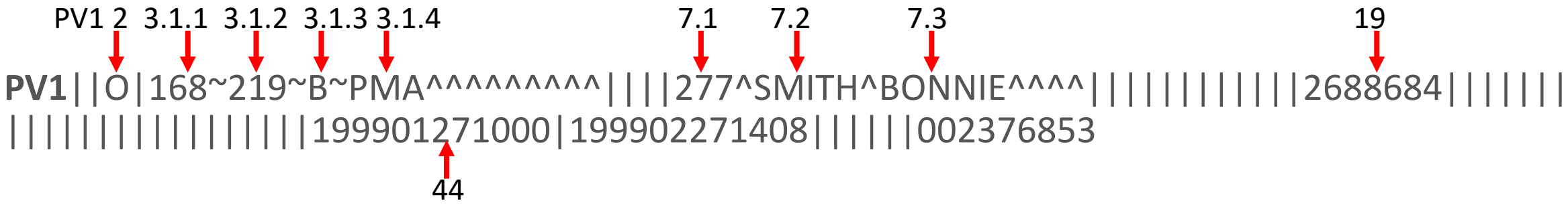
- **MSH|**^~\&|EPIC|EPICADT|SMS|SMSADT|**19991227140800**|CHARRIS|**ADT^A04**|1817457|D|2.5|
- Every HL7 message specifies MSH as its first segment
- The pipe symbol (**|**) is the field delimiter which separates fields
- Date-Time Fields are in the format YYYYMMDDHHMMSS
- MSH field 9 is the Message Type (ADT-A04, Patient Registration, in this example)

HL7 Overview: ADT: Patient ID Segment

PID||0493575^^^2^ID1|454721||DOE^JOHN^^^^|DOE^JANE^^^^|19480203|M||B|254MYSTREETAVE^^MYTOWN^OH^44123^USA||(216)1234567|||M|NON|400003403~1129086|550921234|

- PID 1: Empty field. The pipe symbol (**|**) is the field delimiter which separates fields
- PID 2: External ("OLD") Patient ID: For backwards compatibility
- PID 3: Patient ID (i.e., Medical Record Number)
- PID 5.1: Patient Name, starting with Last Name
- PID 5.2: Patient Name, First (Given) Name. This field can continue (^ is the component separator), with Suffix (e.g., Jr, III), Prefix (e.g., Dr), Degree (e.g., MD) and more options.
- PID 6: Mother's Maiden Name
- PID 7 : Birthdate (YYYYMMDD), Birth Time is optional and not shown here
- PID 8: Sex

HL7 Overview: ADT: Patient Visit Segment



- PV1 2: Patient Class (O=Outpatient)
- PV1 3.1 Point of Care (HDO defined “Location Type”)
- PIV1 3.1.2: Room (“219”)
- PV1 3.1.3: Bed (“B”)
- PV1 3.1.4: Facility (“PMA”) in this example)
- PV1 7.1: Attending Doctor ID
- PV1 7.2: Attending Doctor’s Last Name
- PV1 7.3: Attending Doctor’s First Name
- PV1 19: Unique Visit ID
- PV1 44: Admit Date and Time

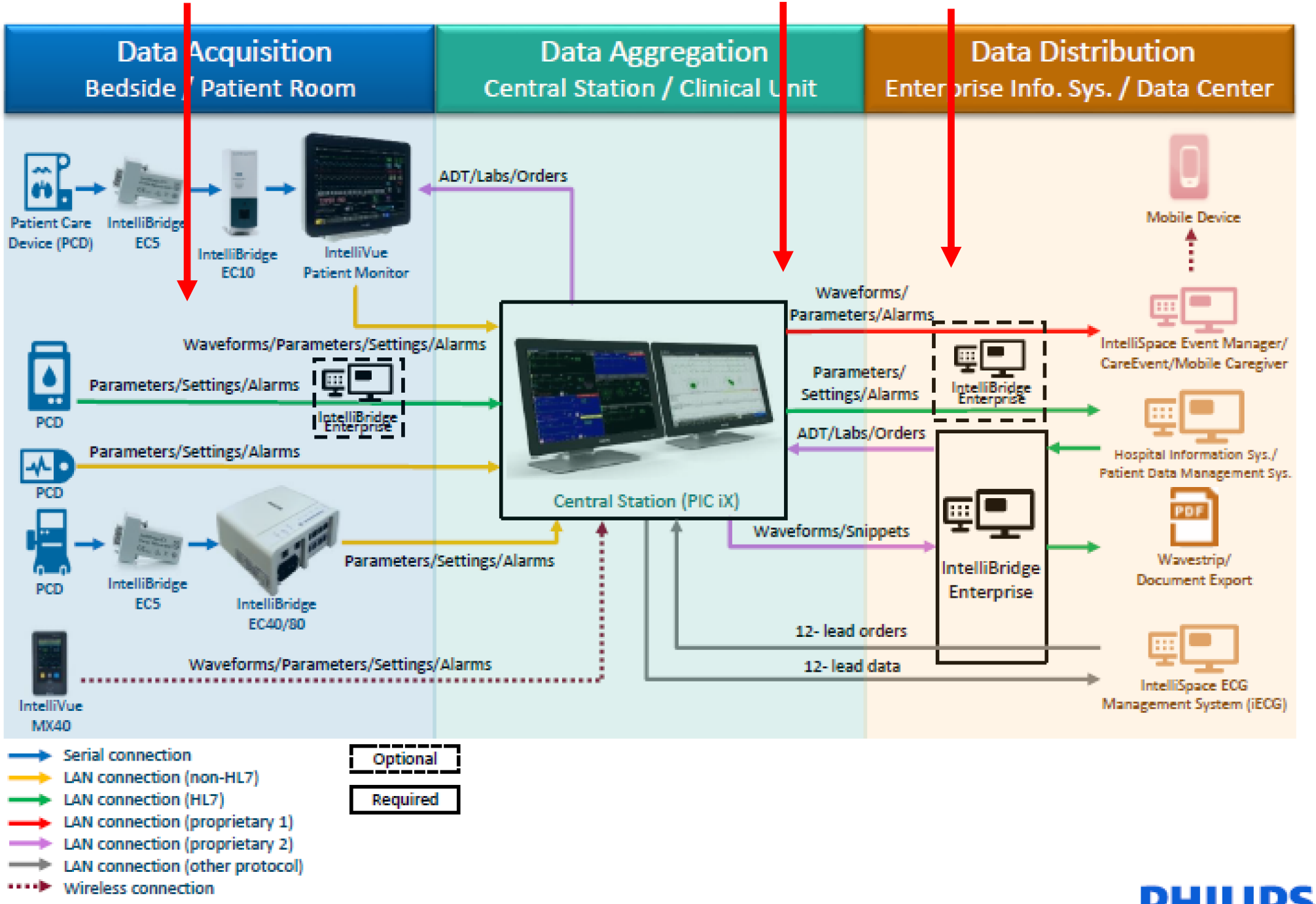
Reference:
https://hl7-definition.caristix.com/v2/HL7v2.3/Segments/PID

Physiological Monitor Integration

Medical devices acquire the data and get the data on the network

Aggregate the data messages. Convert them into an EHR readable format (e.g., HL7)

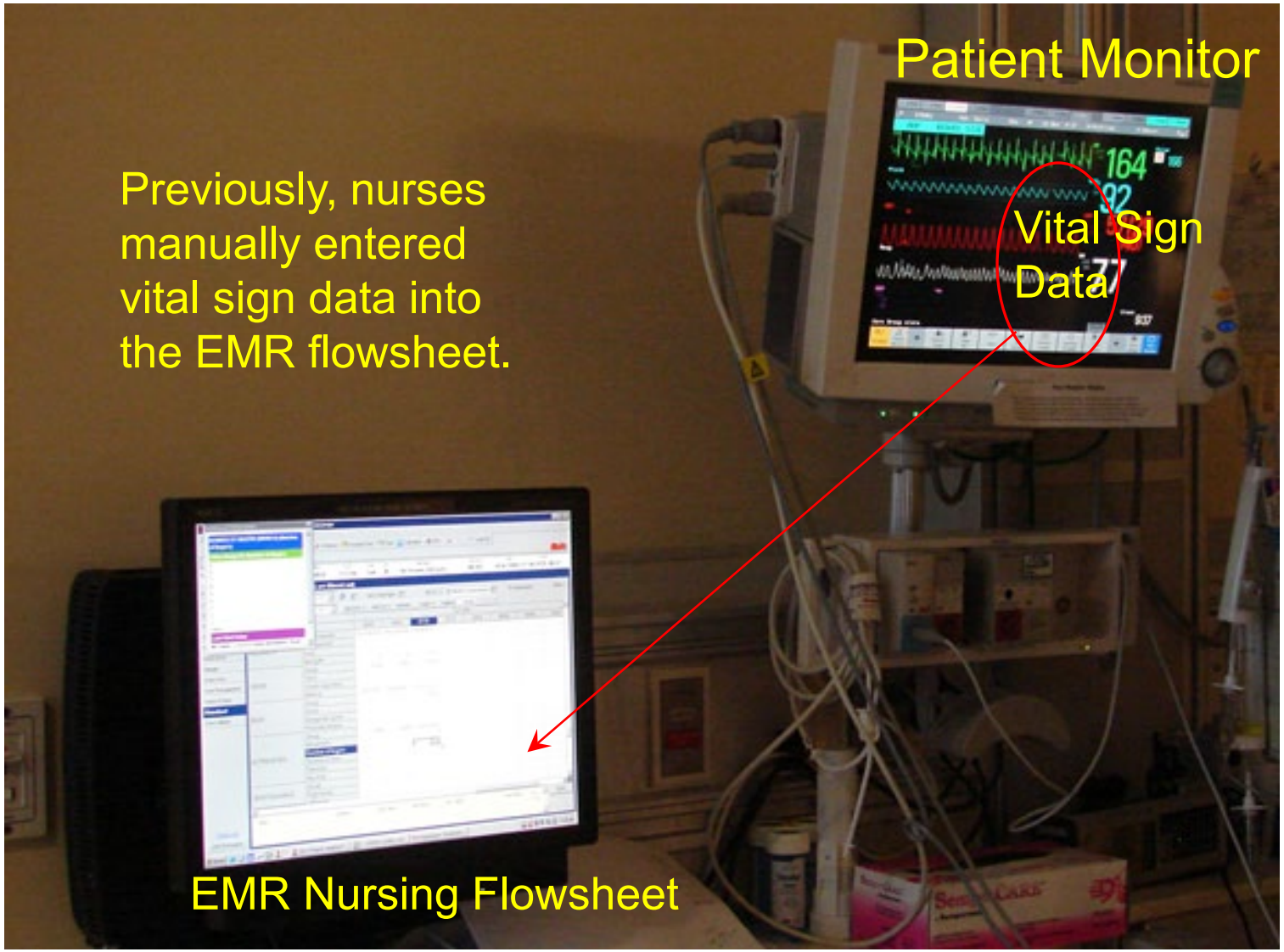
Distribute the data using standardized formats (e.g. HL-7)



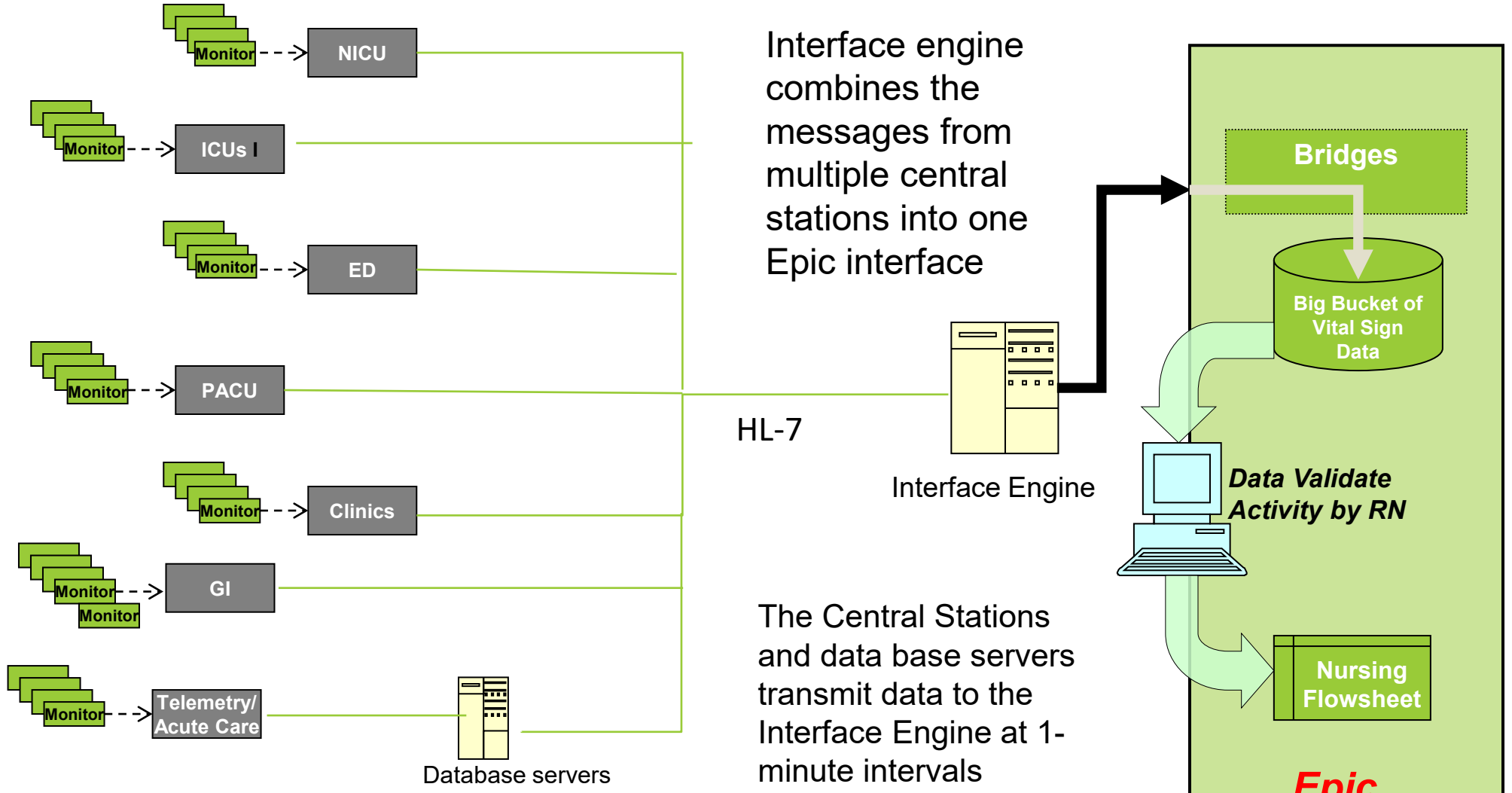
PHILIPS

Monitor Integration

Monitor Integration is the **automatic** transfer of vital sign data from bedside monitors to the Electronic Health Record (EHR).

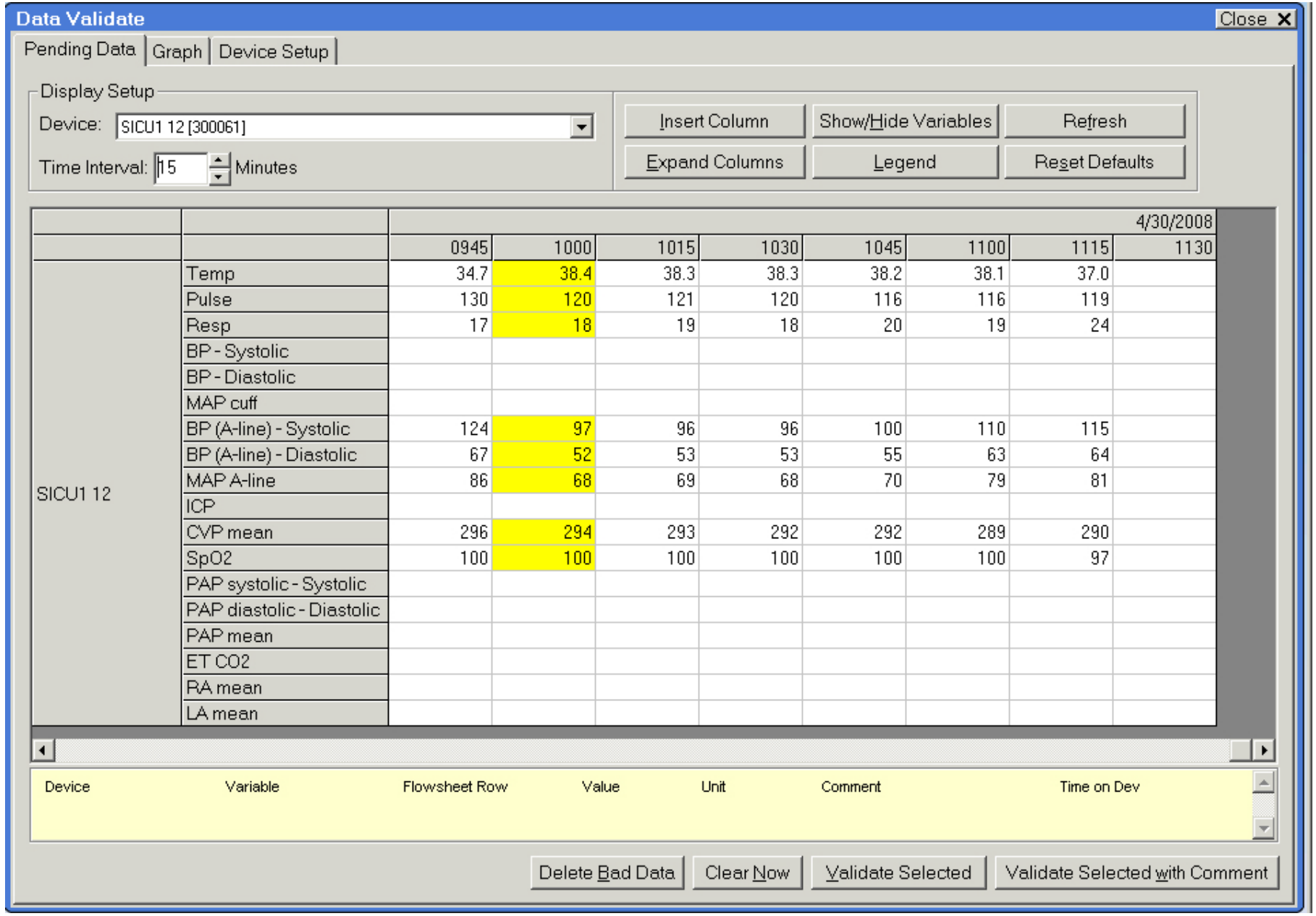


Monitor integration data flow example

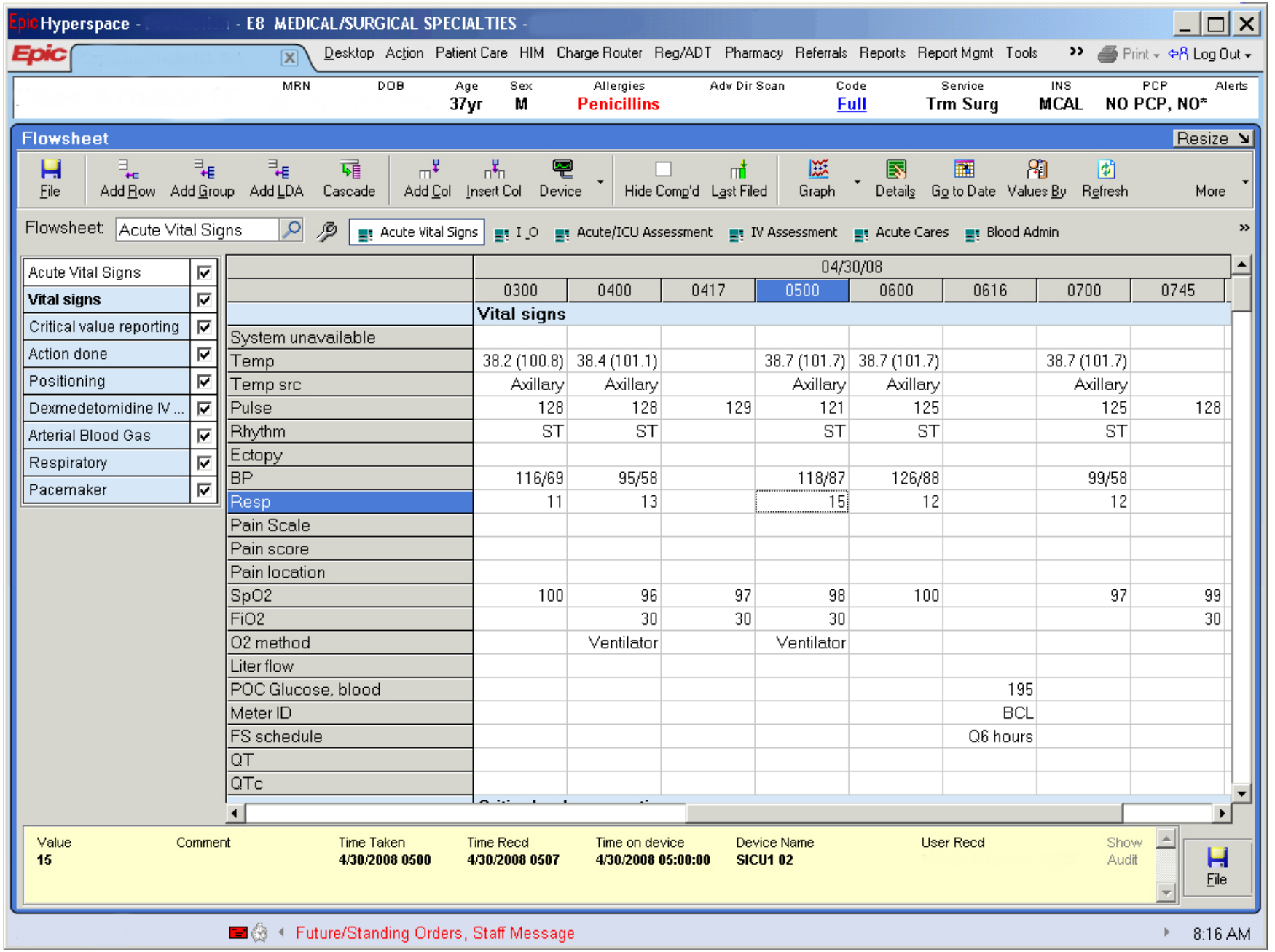


HDO1: ~500 Bedside Monitors – 25 clinical areas

Data Validate Activity



Nursing Flowsheet



HL-7 and medical devices: OBR (Observation request) and OBX (Observation result) Segments

- OBR segment: Header info such as order number, request date/time, observation date/time, ordering provider etc)

- OBX segment: Transmits the actual clinical result/observation as a single observation or observation fragment. OBX segments can be repeated multiple times.

HL-7 Patient Monitor Data Example

MSH|^~\&|||||||ORU^R01|HP1385987680137289 2|P|2.5||||||8859/1
PID|||patient ID info||Ted Cohen||patient ID info|
PV1||||CCU^^CCU04
OBR|||||||20140906142830
OBX||NM|0002-4bb8^SpO2^MDIL|0|96|0004-0220^%^MDIL|||||F
OBX||NM|0002-5000^RR^MDIL|0|16|0004-0ae0^rpm^MDIL|||||F
OBX||NM|0002-4a15^ABPs^MDIL|0|116|0004-0f20^mmHg^MDIL|||||F
OBX||NM|0002-4a16^ABPd^MDIL|0|52|0004-0f20^mmHg^MDIL|||||F
OBX||NM|0002-4a17^ABPm^MDIL|0|72|0004-0f20^mmHg^MDIL|||||F
OBX||NM|0002-4a47^CVPm^MDIL|0|11|0004-0f20^mmHg^MDIL|||||F

Dept ID= CCU, Bed ID=CCU04

Data taken on 09/06/2014 at 14:28:30 for patient Ted Cohen

sPO2= 96, RR (Resp Rate)=16 rpm

ABP = 116/52, mean=72, CVP=11 mm Hg

Exercise: For the HL7 snippet below, answer the questions on the next page

MSH|^~\&||||||ORU^R01|HP104220879017992|P|2.4|||||8859/1<CR>
PID|||MRN5733^^^^MR||Smith^John|Jones^Fran|19550508|M<CR>
PV1||I|^^Doc1&5&1<CR>

OBR||||||20120110152630<CR>

OBX||NM|0002-4bb8^SpO2^MDIL|0|95|0004-0220^%^MDIL||||F<CR>
OBX||NM|0002-5000^Resp^MDIL|0|15|0004-0ae0^rpm^MDIL||||F<CR>
OBX||NM|0002-4182^HR^MDIL|0|60|0004-0aa0^bpm^MDIL||||F<CR>
OBX||NM|0002-4a15^ABPs^MDIL|0|120|0004-0f20^mmHg^MDIL||||F<CR>
OBX||NM|0002-4a16^ABPd^MDIL|0|70|0004-0f20^mmHg^MDIL||||F<CR>
OBX||NM|0002-4a17^ABPm^MDIL|0|91|0004-0f20^mmHg^MDIL||||F<CR>
OBX||NM|0002-4a05^NBPs^MDIL|0|120|0004-0f20^mmHg^MDIL||||F||APERIODIC|20120110152610<CR>
OBX||NM|0002-4a06^NBPd^MDIL|0|80|0004-0f20^mmHg^MDIL||||F||APERIODIC|20120110152610<CR>
OBX||NM|0002-4a07^NBPm^MDIL|0|90|0004-0f20^mmHg^MDIL||||F||APERIODIC|20120110152610<CR>
OBX||NM|0002-50b0^etCO2^MDIL|4|7.08|0004-0220^%^MDIL||||F<CR>

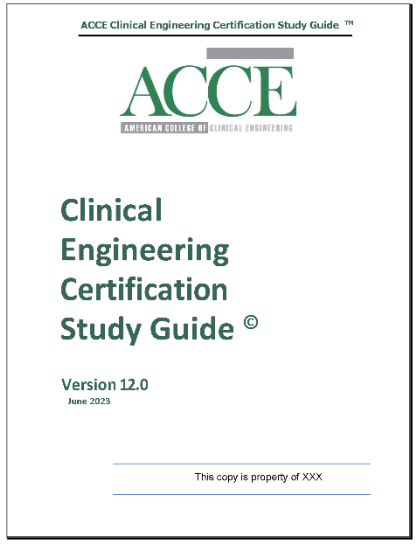
Exercise: Please answer the questions below for the HL7 snippet on previous page)

1. What version of HL7 is this clip from?
2. What is the patient's name?
3. At what time was (patient name's) heart rate taken?
4. What is (patient name's) non-invasive blood pressure?
5. At what time was NBP taken?
6. What is (patient name's) end-tidal CO?, What units?

References

- HTTPS://WWW.HL7.ORG

- HTTPS://HL7-DEFINITION.CARISTIX.COM/V2/HL7V2.3/SEGMENTS/PID



ACCE CCE Study Guide, v12.0, 2023

ACCE
AMERICAN COLLEGE OF CLINICAL ENGINEERING

Ted Cohen, MS, CCE, FACCE
tedcohen@pacbell.net

Please complete the evaluation form at: https://www.surveymonkey.com/r/2023-session7

or scan the QR code: