Vision on Medical Device Plug-and-Play

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Existing Efforts

Vision and Roadmap

Why do we want Medical Device Plug-and-Play (MDPnP)? (and why wireless MDPnP?)

Flexibility and expanded medication capability

Safety

Convenience and Efficiency

Independence from device vendors

Hundreds of thousands of medical devices exist in nowadays hospitals, but are mostly designed for isolated use (proprietary)

Monitors

Oximeter

Infusion Pumps

Bar Code Scanner

BP

Cell / PDA

Tablet PC

Workstation

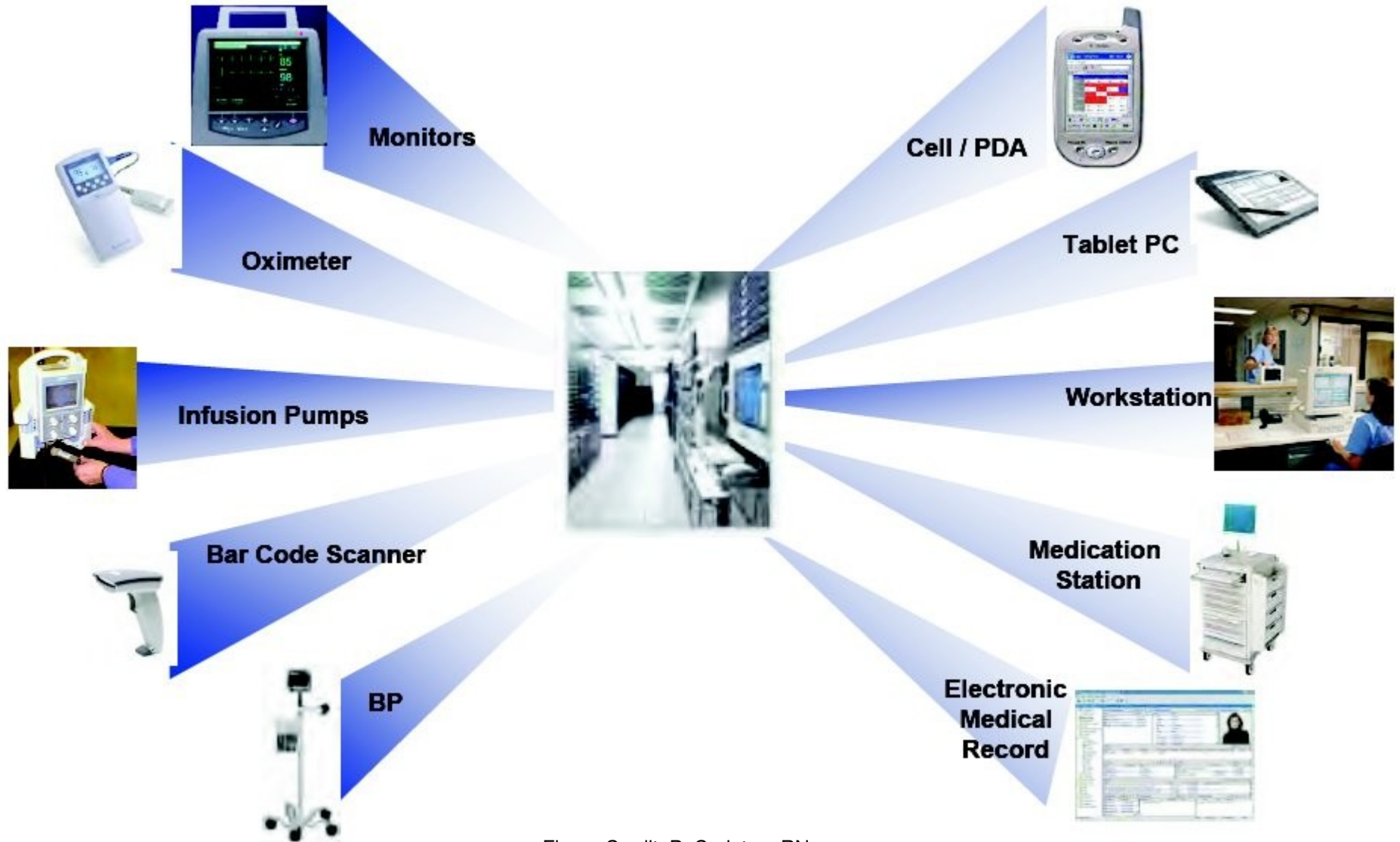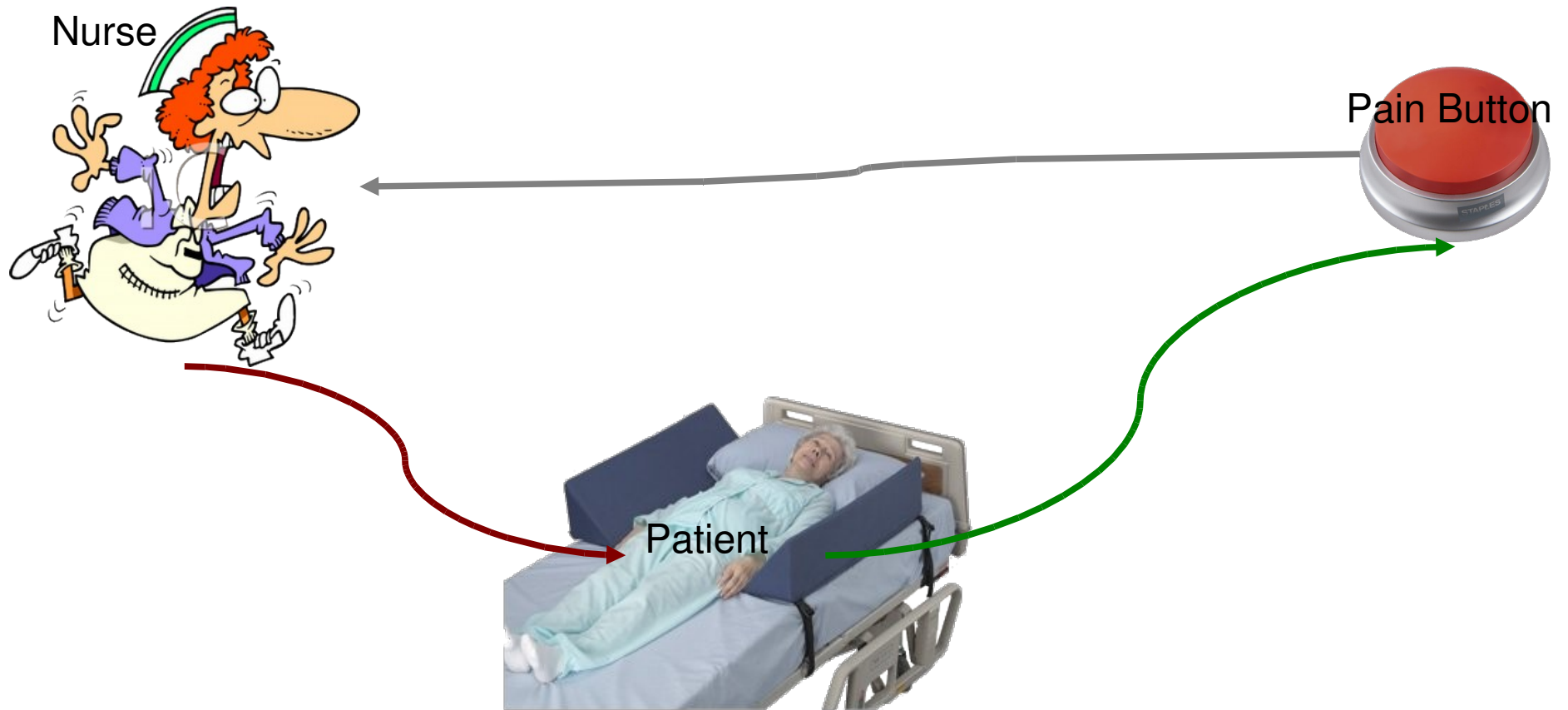Medication Station

Electronic Medical Record

Figure Credit: P. Carleton, RN

Flexible composition of medical devices expands medication capability by enabling new methods/apps

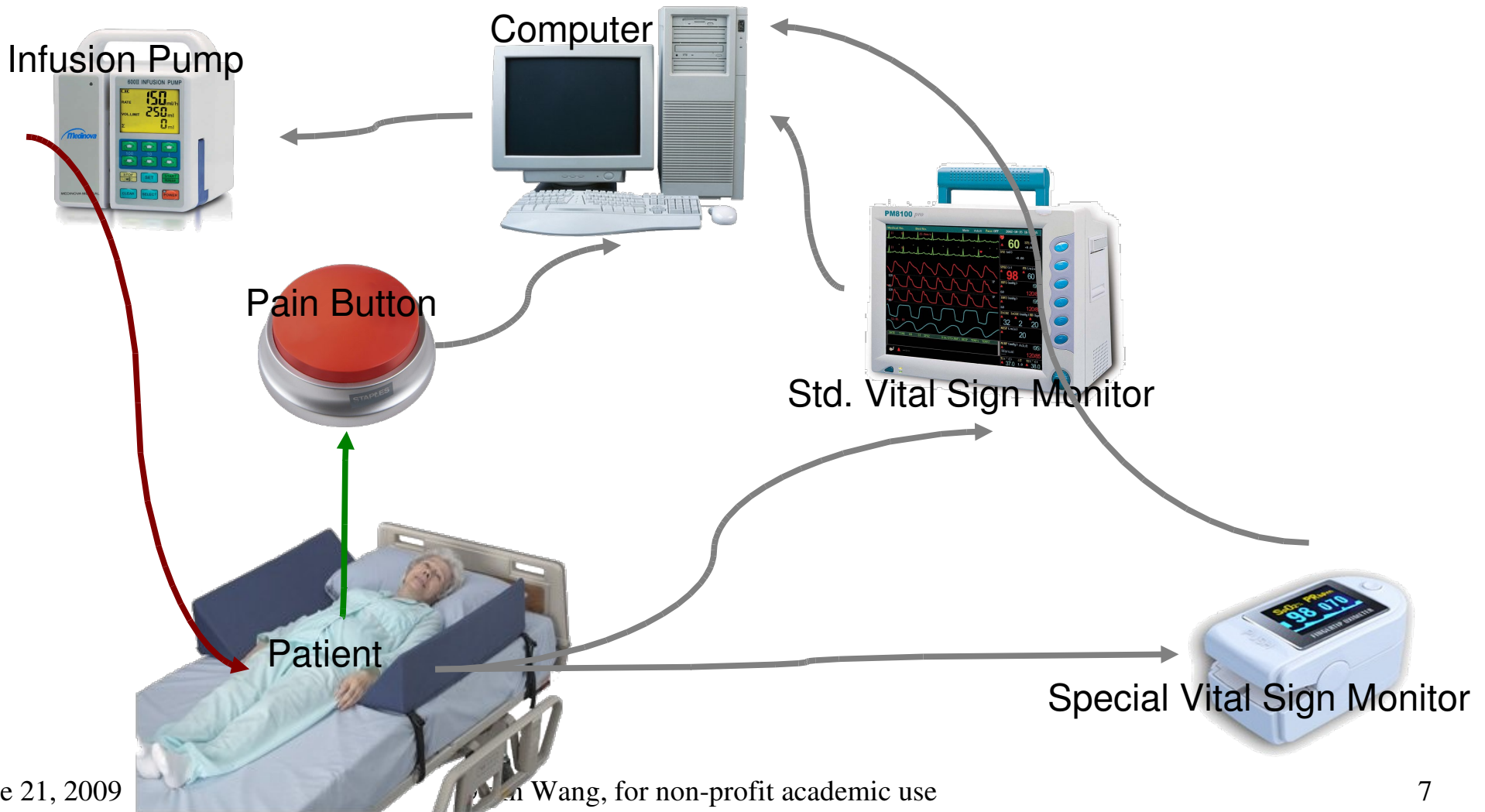Patient Controlled Anesthesia (PCA)

Nurse

Pain Button

Patient

Flexible composition of medical devices expands medication capability by enabling new methods/apps

Patient Controlled Anesthesia (PCA)

Infusion Pump

Computer

Pain Button

Std. Vital Sign Monitor

Patient

Special Vital Sign Monitor

We need interconnected/interlocked medical devices to provide safety

Blood Pressure Measuring

47/74

Correct

We need interconnected/interlocked medical devices to provide safety
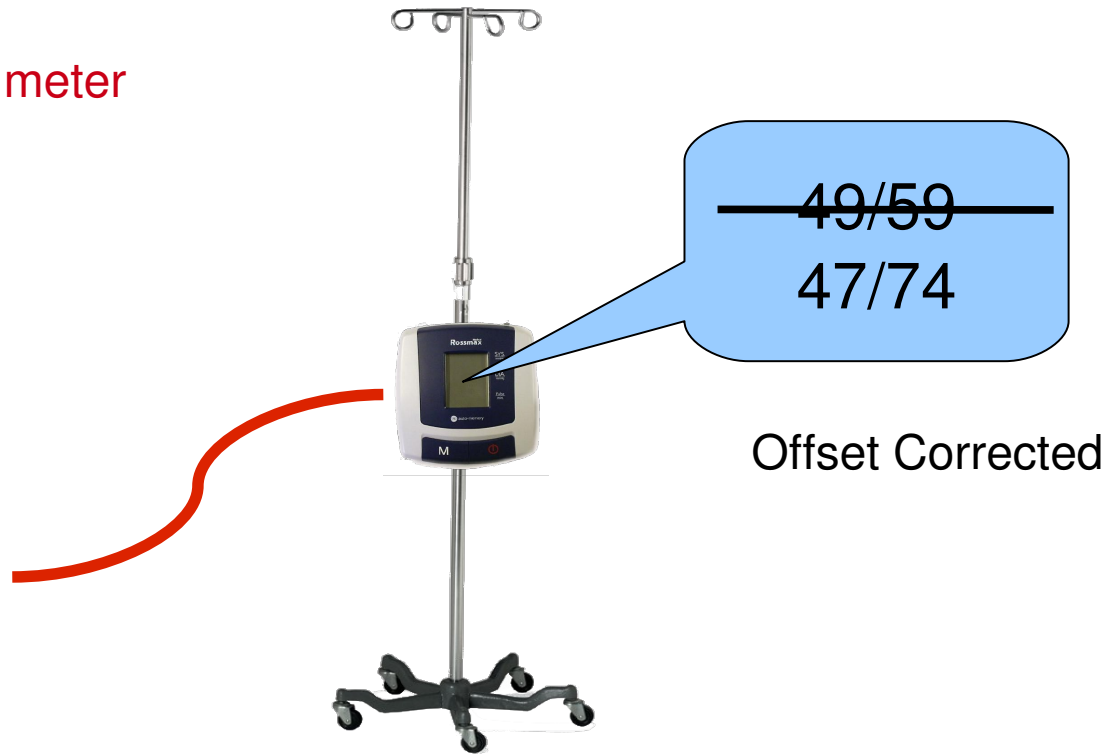
Blood Pressure Measuring

49/59

Error: too low
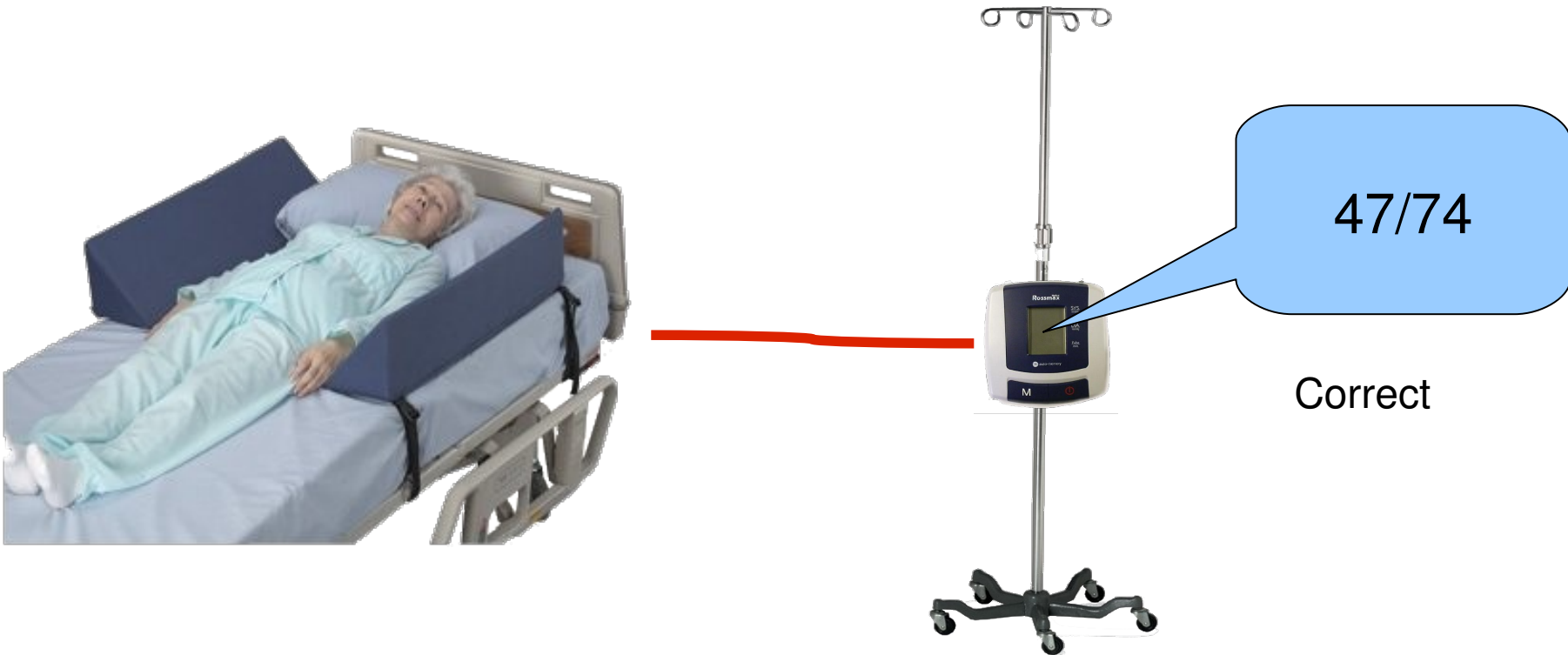
We need interconnected/interlocked medical devices to provide safety

Blood Pressure Measuring

Proposal:
MDPnP interlocked Bed and BP meter

~~49/59~~

47/74

Offset Corrected

We need interconnected/interlocked medical devices to provide safety

Cardiopulmonary Bypass v.s. Ventilator Accident

Ventilator

Heart Lung Machine

Correct Procedure:

We need interconnected/interlocked medical devices to provide safety

Cardiopulmonary Bypass v.s. Ventilator Accident

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Absent Minded Procedure:

We need interconnected/interlocked medical devices to provide safety

Cardiopulmonary Bypass v.s. Ventilator Accident

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Absent Minded Procedure:
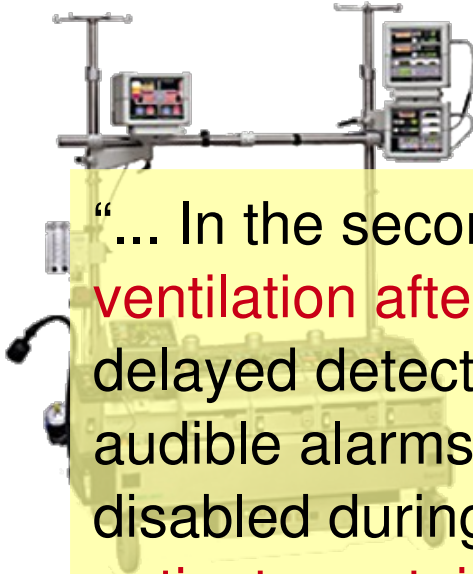
We need interconnected/interlocked medical devices to provide safety

Cardiopulmonary Bypass v.s. Ventilator Accident

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Heart Lung Machine

Absent Minded Procedure:

We need interconnected/interlocked medical devices to provide safety

Cardiopulmonary Bypass v.s. Ventilator Accident

Ventilator

Heart Lung Machine

Absent Minded Procedure:

"... In the second case, the anesthesiologist forgot to resume ventilation after separation from cardiopulmonary bypass. The delayed detection of apnea was attributed to the fact that the audible alarms for the pulse oximeter and capnograph had been disabled during bypass and had not been reactivated. Both patients sustained permanent brain damage."

Anesthesiology. 87(4):741-748, October 1997

We need interconnected/interlocked medical devices to provide safety
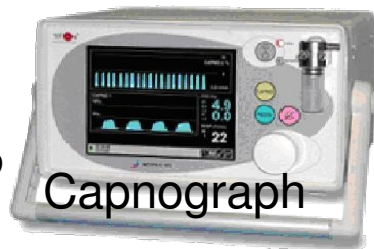
Cardiopulmonary Bypass v.s. Ventilator Accident

Ventilator

Heart Lung Machine

Proposal:
MDPnP Interlocked Architecture

MDPnP Control Computer

Capnograph

Oximeter

We need interconnected/interlocked medical devices to provide safety

X-Ray v.s. Ventilator Accident

Qixin Wang, for non-profit academic use

Picture provided by Mu Sun
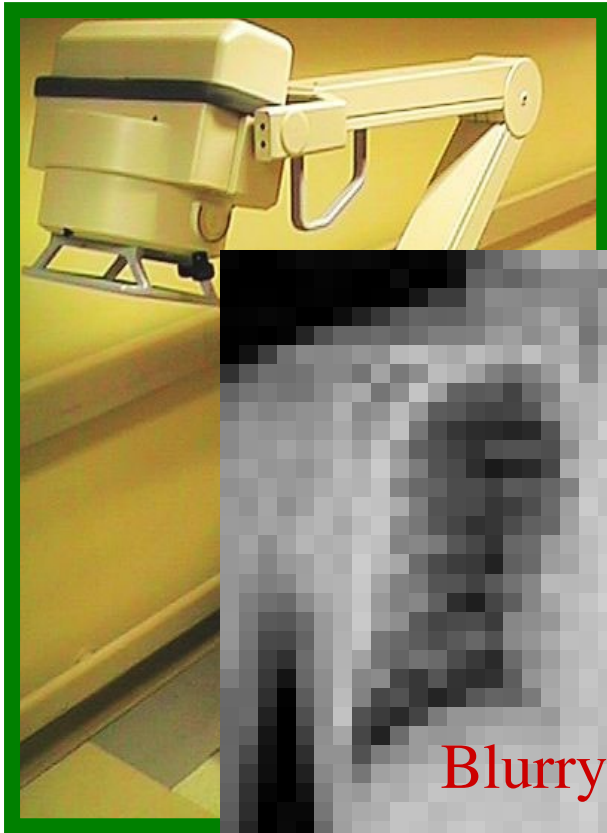
We need interconnected/interlocked medical devices to provide safety

X-Ray v.s. Ventilator Accident

Blurry Image

Qixin Wang, for non-profit academic use

Picture provided by Mu Sun

We need interconnected/interlocked medical devices to provide safety

X-Ray v.s. Ventilator Accident

Qixin Wang, for non-profit academic use

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X-Ray v.s. Ventilator Accident

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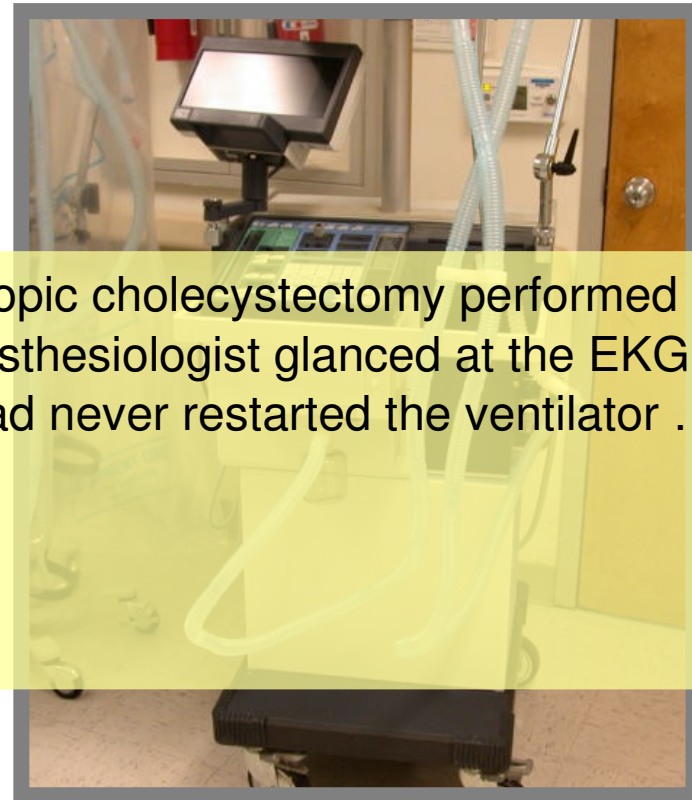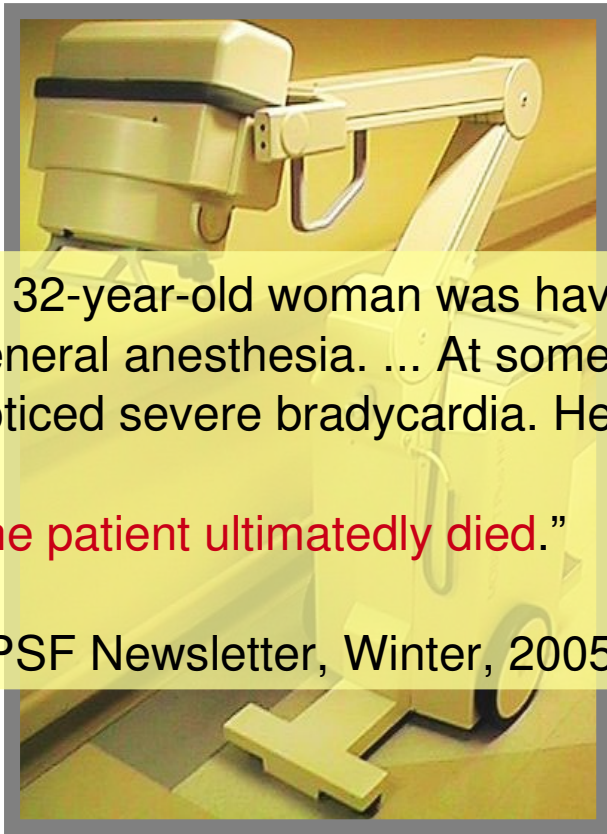
We need interconnected/interlocked medical devices to provide safety

X-Ray v.s. Ventilator Accident

"A 32-year-old woman was having a laparoscopic cholecystectomy performed under general anesthesia. ... At some point, the anesthesiologist glanced at the EKG and noticed severe bradycardia. He realized he had never restarted the ventilator …

The patient ultimatedly died."

APSF Newsletter, Winter, 2005.

Picture provided by Mu Sun

We need interconnected/interlocked medical devices to provide safety

X-Ray v.s. Ventilator Accident

Proposal:

MDPnP interlock of X-Ray and Ventilator

Picture provided by Mu Sun
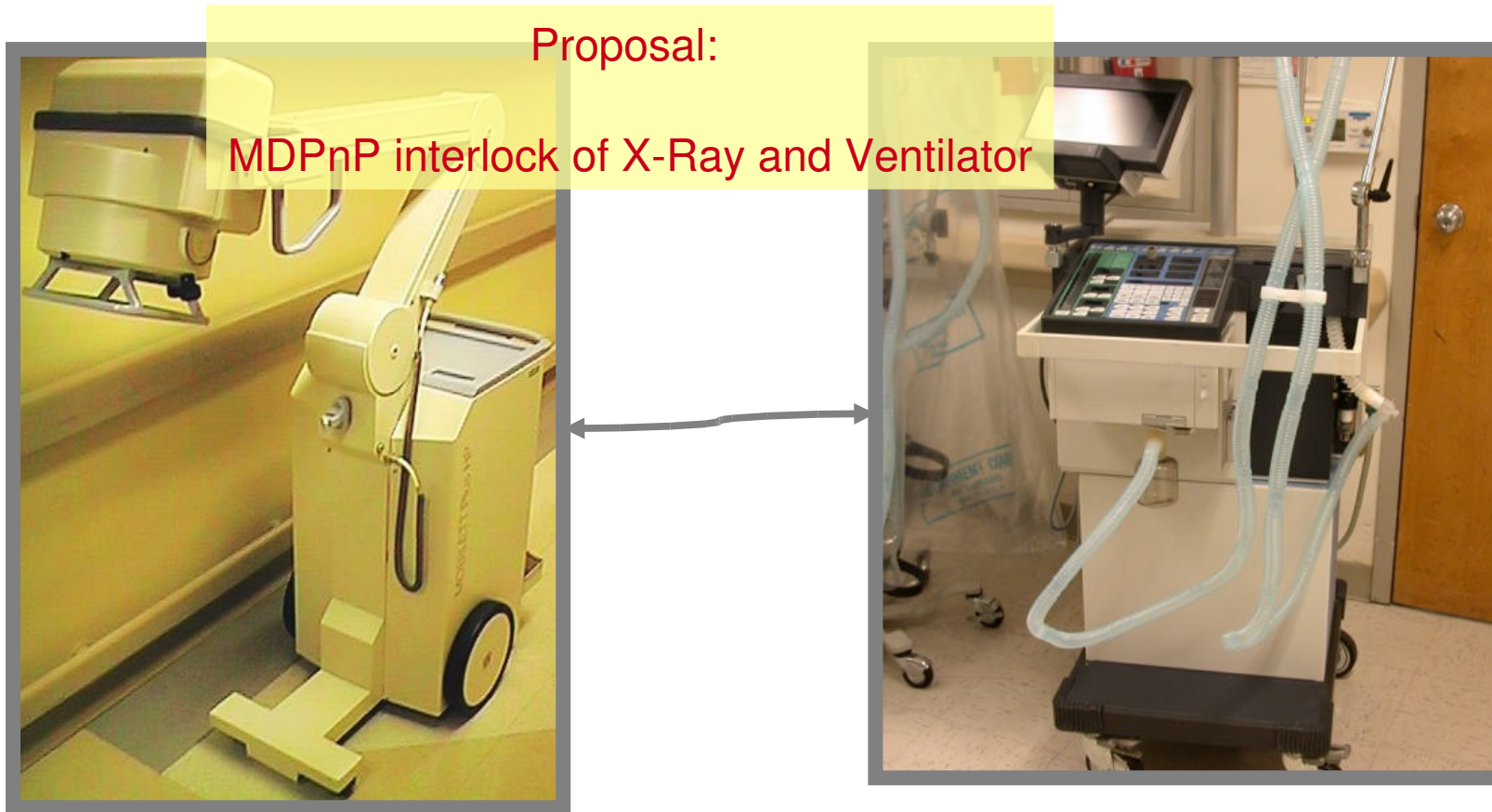
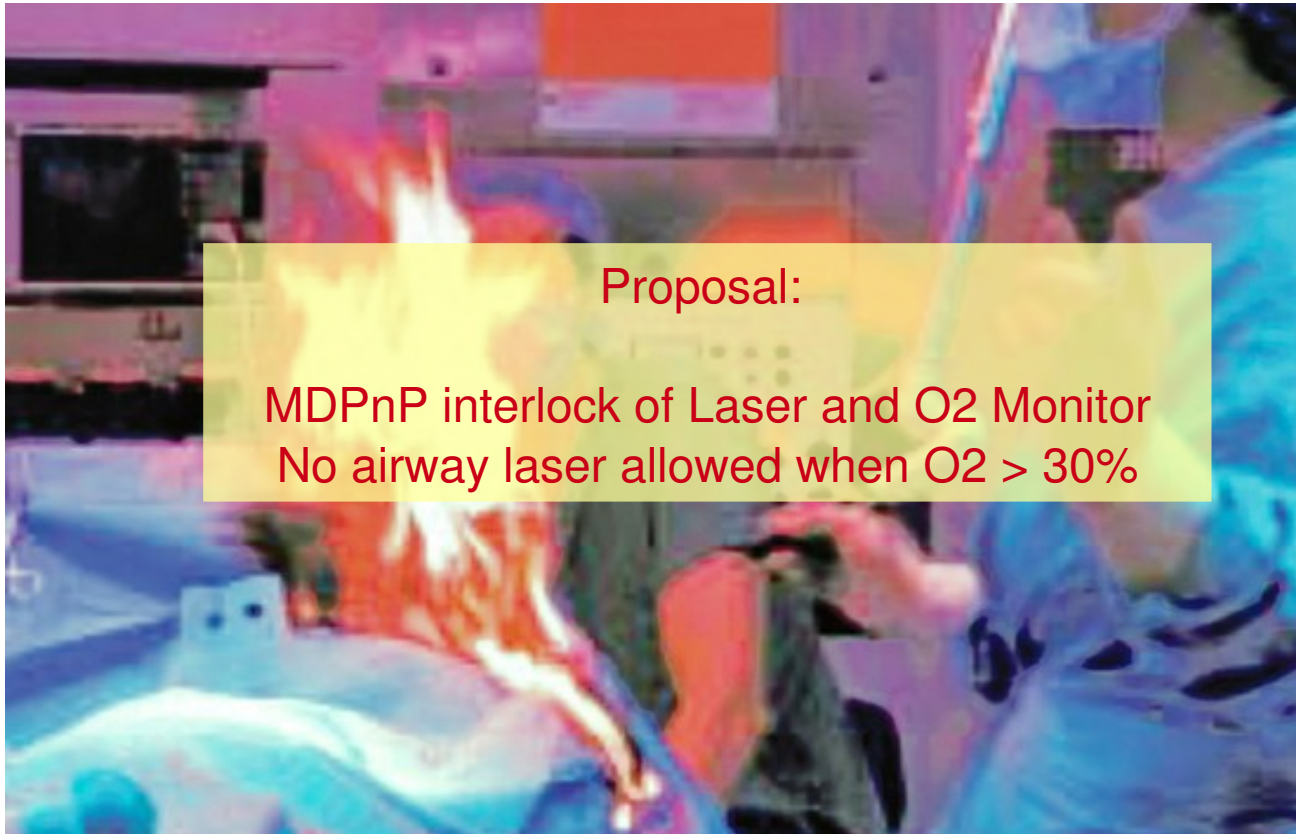# We need interconnected/interlocked medical devices to provide safety

Laser v.s. Oxigen Concentration Accident

We need interconnected/interlocked medical devices to provide safety

Laser v.s. Oxigen Concentration Accident

Proposal:

MDPnP interlock of Laser and O2 Monitor
No airway laser allowed when O2 > 30%

We need interconnected/interlocked medical devices to provide safety

Contangeous patient calls nurse for help
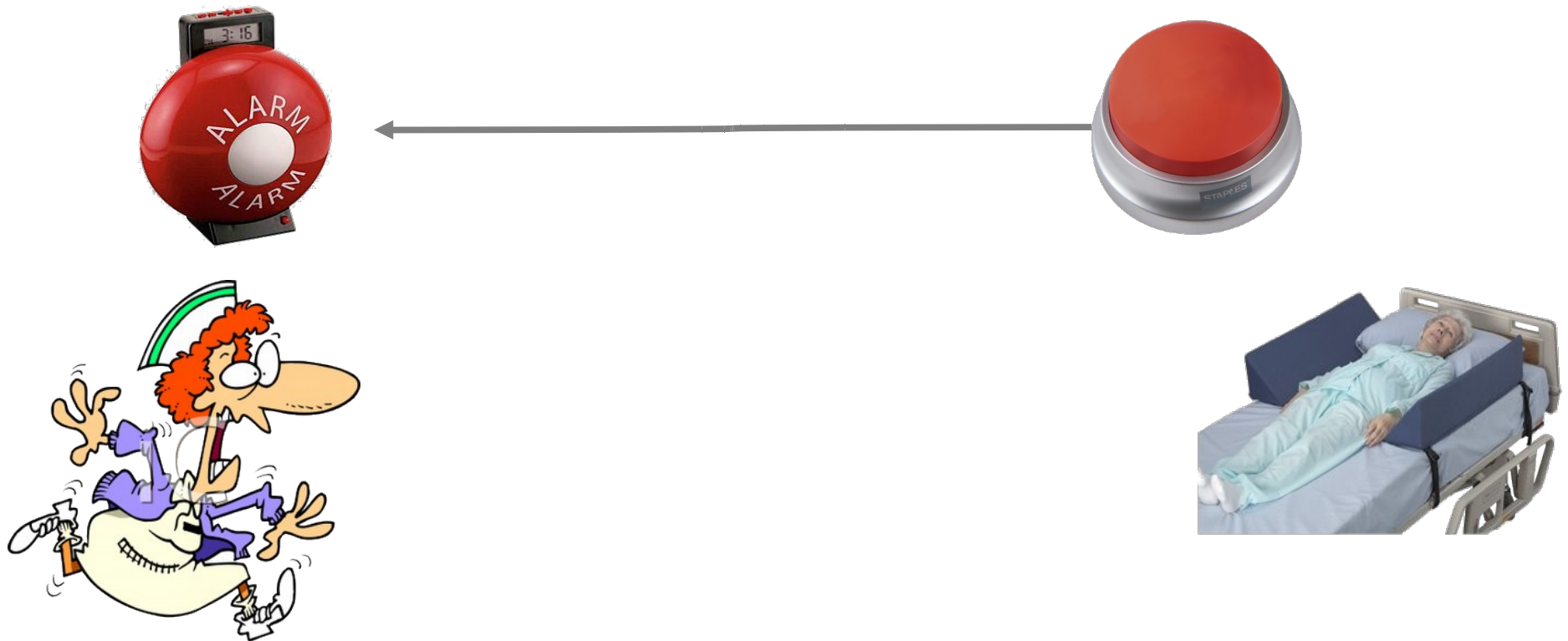
We need interconnected/interlocked medical devices to provide safety

Contangeous patient calls nurse for help

Contageous, must wear mask!

We need interconnected/interlocked medical devices to provide safety

Contangeous patient calls nurse for help

Contageous, must wear mask!

EMR DB

MDPnP connection of EMR DB, Nurse Station, and Vital Sign Monitors
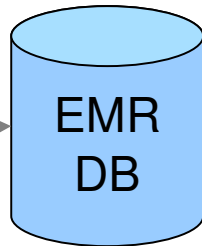
ALARM

Nurse Station

MDPnP, particularly wireless MDPnP, improves convenience and efficiency

Messed Up Operation Room

High-acuity care today:
How do we prevent errors?
How do we keep track of all this?

Picture quoted from www.mdpnp.org

MDPnP, particularly wireless MDPnP, improves convenience and efficiency

Messed Up OR v.s. Vital Sign Bulletin Board

Qixin Wang, for non-profit academic use

Picture quoted from www.mdpnp.org

MDPnP, particularly wireless MDPnP, improves convenience and efficiency

Messed Up OR v.s. Vital Sign Bulletin Board

LiveData OR Dashboard

Picture quoted from www.mdpnp.org

MDPnP, particularly wireless MDPnP, improves convenience and efficiency

The Operation Room Spider Web

Picture quoted from www.mdpnp.org
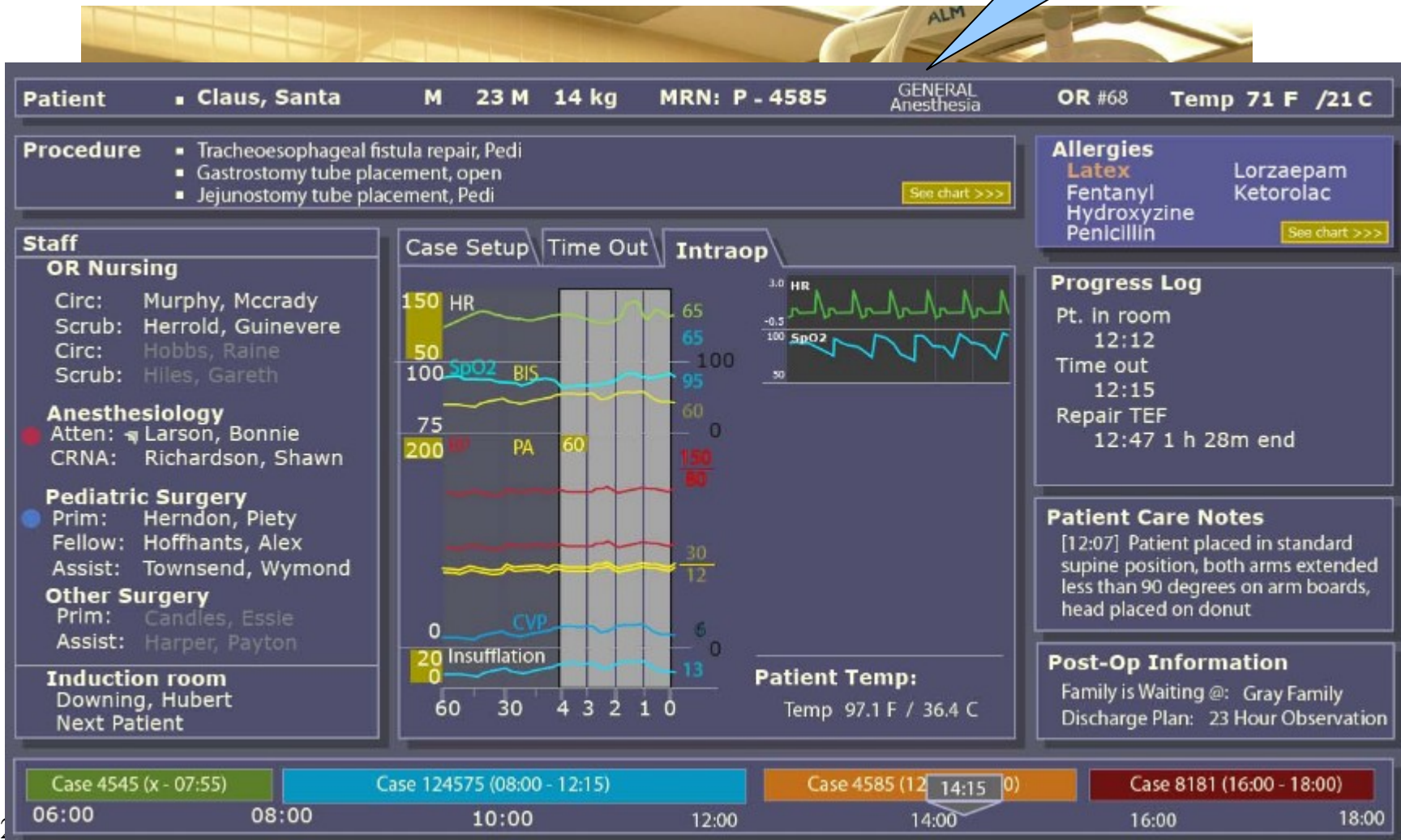
MDPnP, particularly wireless MDPnP, improves convenience and efficiency

The Operation Room Spider Web,
after MDPnP safety interlocks

Picture quoted from www.mdpnp.org
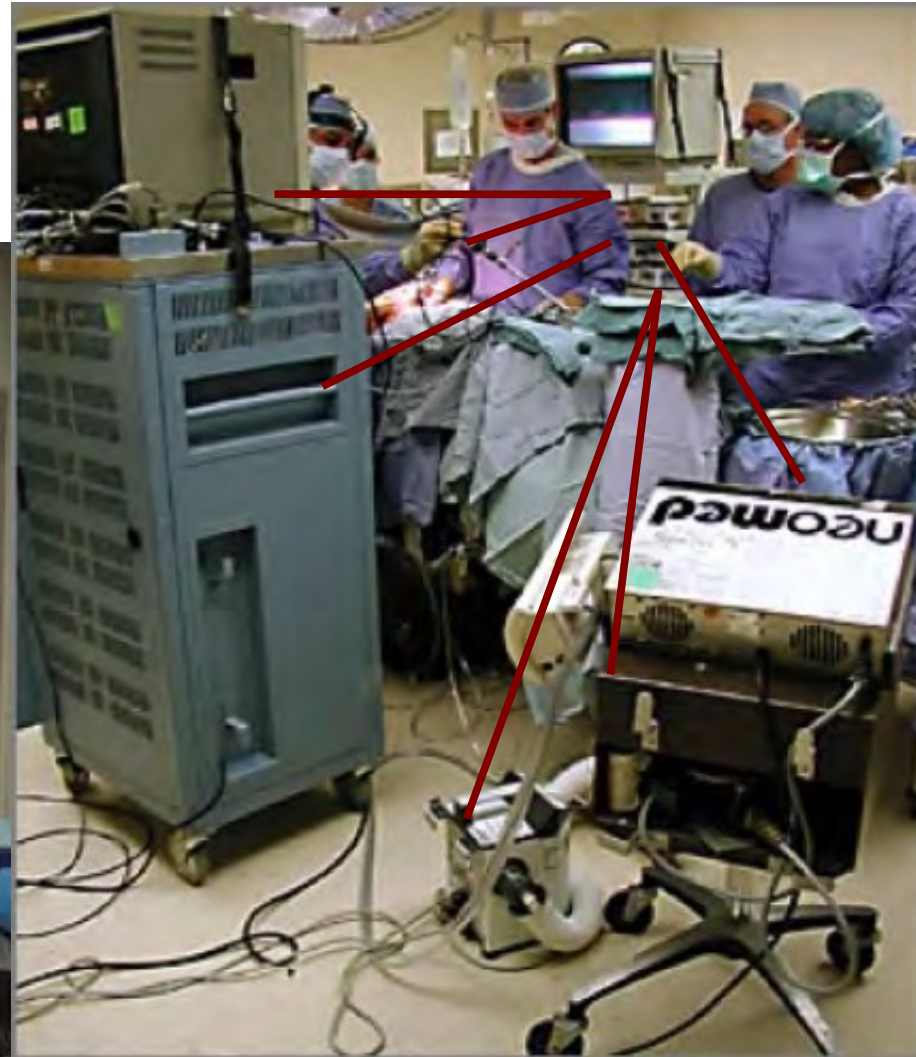
MDPnP, particularly wireless MDPnP, improves convenience and efficiency

Spider Web OR v.s. Wireless OR

Qixin Wang, for non-profit academic use

Picture quoted from www.mdpnp.org

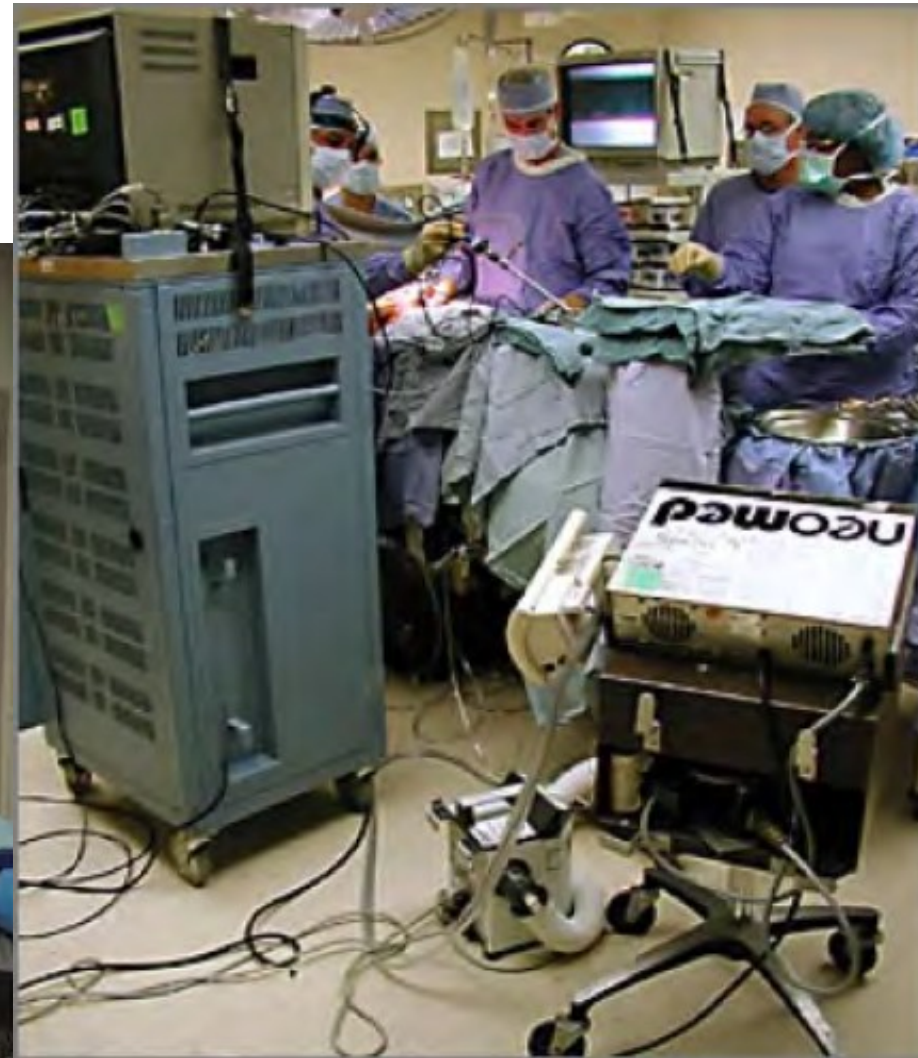**Independence**: hospitals need hundreds of thousands of types of medical devices; don't want to be controlled by one vendor.

Monitors
Oximeter
Infusion Pumps
Bar Code Scanner
BP
Cell / PDA
Tablet PC
Workstation
Medication Station
Electronic Medical Record
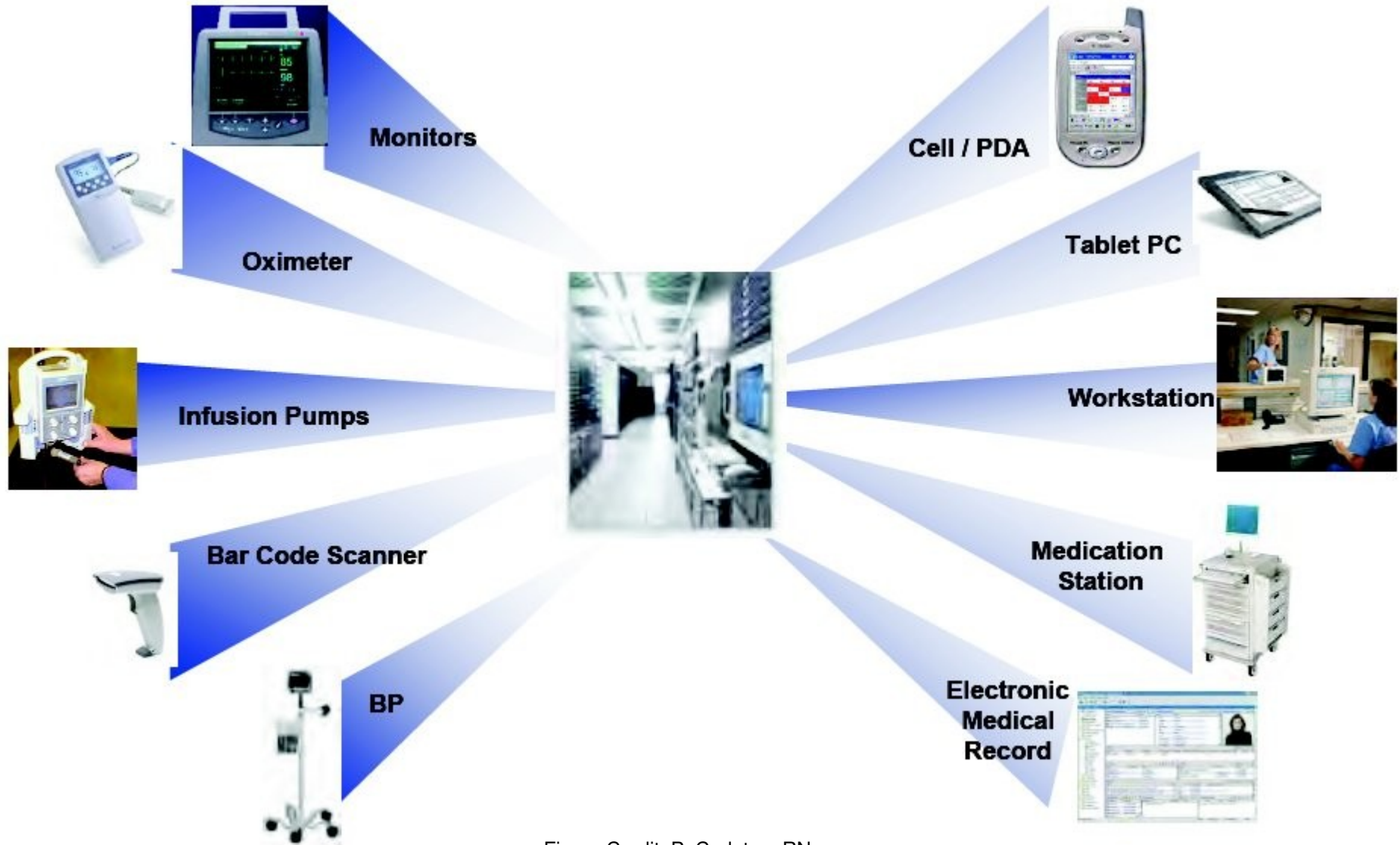
Figure Credit: P. Carleton, RN

Why do we want Medical Device Plug-and-Play (MDPnP)? (and why wireless MDPnP?)

Flexibility and expanded medication capability

Safety

Convenience and Efficiency

Independence from device vendors

MDPnP benefits whom?

Hospitals: independence, medication capability, safety

Doctors: medication capability, safety, convenience

Patient: medication capability, safety, cost

Government: tracktability, cost

Vendors: larger market

Academia: typical case of cyber-physical systems

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Existing Efforts

Vision and Roadmap

IEEE 1073 Committee

IEEE 1073 (5/1996): overall network/middleware architecture

ISO/IEEE 11073-10101 (6/2004): nomenclature

ISO/IEEE 11073-20601 (9/2008): middleware group management and communication protocol guideline

ISO/IEEE 11073-30200 (1/2000): cable PHY ~ transportation layer

ISO/IEEE 11073-10441 (1/2009): device spec. – cardiovascular fitness and activity monitor

American Society for Testing and Materials (ASTM), International Standardization

Draft ASTM TC F29.21 N21 (2008):

Medical Devices and Medical Systems – Essential safety requirements for equipment comprising the patient-centric integrated clinical environment (ICE) – Part 1: General requirements and conceptual architecture

US Government Efforts

FDA:

Draft Guidance for Industry and FDA Staff: Radio-Frequency Wireless Technology in Medical Devices, draft released for comment on Jan 3, 2007

US Government Efforts

President's Council of Advisors on Sci. & Tech. (PCAST):

2007 Report on Federal Networking and Information Technology R&D list Cyber-Physical Systems as the top of the eight priorities for federal research investments.

US Government Efforts

NSF:

Call for Proposals: Cyber-Physical Systems (CPS), solicitation 08-611, deadline: Feb., 2010.

"... Research advances in cyber-physical systems promise to … enhance societal wellbeing (e.g., assistive technologies and ubiquitous healthcare monitoring and delivery) … NSF … are spear-heading the Cyber-Physical Systems (CPS) program becaues of its … impact … critical to U.S. Security and competitiveness, including … healthcare ..."

US Government Efforts

National Coordination Office for Networking and Information Technology Research and Development Program (NCO/NIRTD):

High-Confidence Medical Devices: Cyber-Physical Systems for 21st Century Health Care, Feb., 2009

Industry and Academia Efforts

MDPnP: http://www.mdpnp.org, initiators:

- NIST (National Institute for Standards and Technology)
- NSF (National Science Foundation)
- Society for Technology in Anesthesia
- DocBox
- Philips Healthcare
- Etc.

Industry and Academia Efforts

MDPnP: http://www.mdpnp.org, initiators:

Conference: June 2007

s from June conference agenda available at
//www.cimit.org/mdpnpjune07/start.htm

Proceedings published by IEEE

32

48

Source: www.mdpnp.org

Industry and Academia Efforts

CIMIT: http://www.cimit.org

Center for Integration of Medicine & Innovative Technology, a non-profit consortium initiated by 12 institutes, including Mass. Gen. Hospital, Harvard Medical School, MIT,VA Boston Healthcare System etc.

More than 40 industry partners.

Industry and Academia Efforts

IEEE Computer: Insup Lee, George J. Pappas, Rance Cleaveland, John Hatcliff, Bruce H. Krogh, Peter Lee, Harvey Rubin, Lui Sha: High-Confidence Medical Device Software and Systems. IEEE Computer 39(4): 33-38 (2006)

CPS Week: since 2008 (NSF CPS Summit), involving RTAS, IPSN, HSCC

CPS Track: since 2007, IEEE RTSS

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Healthcare CPS can involve and stimulate the growth of nearly every CS area.