How the Internet of Things Can Save 50,000 Lives a Year

It is the 6th leading cause of preventable death in the US.[1] It kills over 50,000 people every year in the US alone, and likely 10 times more worldwide. That's like crashing three jumbo jets—every single day.

It harms one in seven of those hospitalized under Medicare. It costs the US government over four billion dollars each year.[2] It frustrates caring doctors and nurses every day. The stories tear your heart out: Infants that will never see their homes. Schoolchildren lost to grieving parents. Grandparents whose wisdom will never again enlighten their families. Even worse, this problem has the unique capability to devastate those same caring professionals who have taken an oath to save lives.

What is this killer? Car accidents? Suicide? Guns? Drug abuse? No, those all kill fewer people. The problem is preventable hospital error. Thousands and thousands of errors occur in hospitals every day. Catching them, or even tracking them, is frustratingly ad hoc. Soon, however, connectivity and intelligent distributed medical systems will dramatically improve this forever. This is the revolution that the Internet of Things (IoT) promises for patient safety.

This problem is not new. Thirty years ago, the last major change in health care system technology changed hospital care through a simple realization: monitoring patients improves outcomes. That epiphany spawned the dozens of devices that populate every hospital room: pulse oximeters, multi-parameter monitors, electrocardiogram (ECG) monitors and more. Over the ensuing years, technology and intelligent algorithms improved many other medical devices, from infusion pumps (IV drug delivery) to ventilators. Healthcare is much better today because of these advances. But errors persist.

Why? Today, these devices all operate independently. There's no way to combine the information from multiple devices and intelligently understand patient status. Devices therefore issue many nuisance alarms. Fatigued healthcare staff members silence the alarms, misconfiguration goes unnoticed and dangerous conditions go unaddressed. People die. Consider Figure 1. There are 14 infusion pumps shown in the picture. Each administers a different drug to a single patient.

The pumps are completely independent from each other and the other devices and monitors. This picture is of an Intensive Care Unit (ICU); an operating room (OR) needs a similar array. During a heart surgery, for instance, drugs sedate the patient, stop the heart, start the heart and more. Each drug needs its own delivery device, and there are many more devices, including monitors and ventilators. During surgery, a trained anesthesiologist orchestrates delivery and monitors status. The team has their hands full.
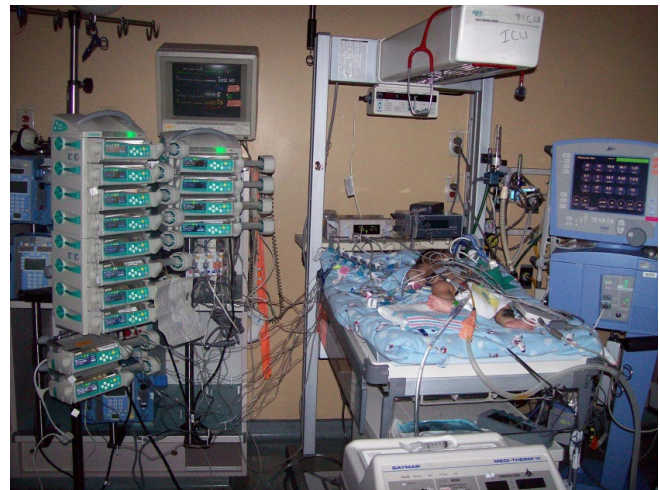

Figure 1. Medical Device Complexity Problem.

After surgery, the patient must transfer to the Intensive Care Unit (ICU). This is a key risk moment. The drug delivery and monitor constellation must be copied from the operating room to the ICU. Today, the OR nurse calls the ICU on the phone and reads the prescription from a piece of paper. The ICU staff must then scramble to find and configure the correct equipment. The opportunity for small slips in transcription, coupled with the time criticality of the change, is fertile ground for deadly error.

Consider if instead these systems could work together in real time. The OR devices, working with a smart algorithm processor, could communicate the exact drug combinations to

[1] http://en.wikipedia.org/wiki/List_of_preventable_causes_of_death

[2] Department of Health and Human Services, Office of Inspector General. Adverse Events in Hospitals. National Incidence in Medicare Beneficiaries. Nov 2010. (QEI 06-09-00090)

Layered Transports Architecture

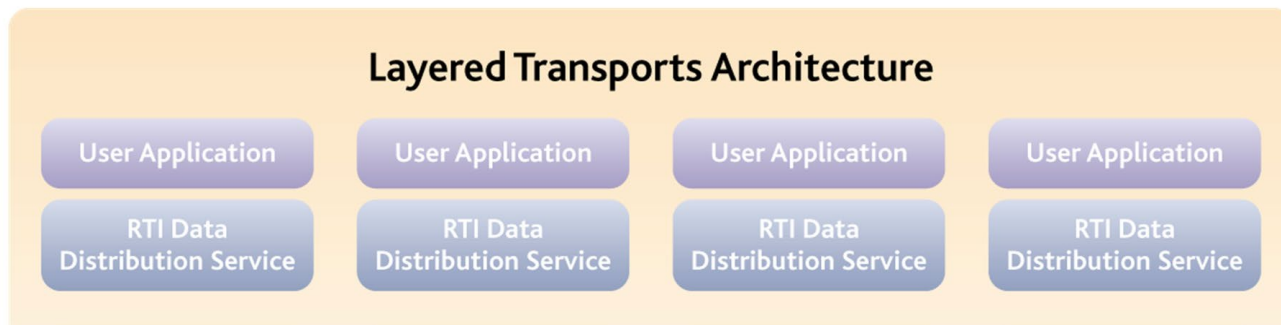| User Application	User Application	User Application	User Application
RTI Data Distribution Service	RTI Data Distribution Service	RTI Data Distribution Service	RTI Data Distribution Service

Figure 2. Patient Controlled Analgesia (PCA).

the Electronic Medical Record (EMR). The ICU system would check this data against its configuration. Paper and manual configuration produce far too many errors; this connected system eliminates dozens of opportunities for mistakes.

Once in post op, the danger is not over. Many patients use Patient Controlled Analgesia (PCA) systems (Fig. 2). The PCA system allows the patient to self-administer doses of painkiller medication by pressing a button. The idea is that a patient with sufficient pain medication will not press the button, and therefore be safe from overdose.

PCA is efficient and successful. Millions of patients use it every year. Still, PCA overdose kills 1-3 patients every day in the US.[3] This seemingly simple system suffers from visitor interference, unexpected patient conditions, and (especially) false alarm fatigue.

Connectivity can also help here. For instance, low oximeter readings cause many alarms. They are only likely real problems if accompanied by a low respiratory rate. A smart alarm that checks both oxygen (SPO2) and carbon dioxide (CO2) levels would eliminate many distracting false alarms. An infusion pump that stopped administering drugs in this condition could save many lives.

These are only a few examples. The list of procedures and treatments that suffer from unintended consequences is long. Today's system of advanced devices that cannot work together is rife with opportunity for error. The common weakness: each device is independent. Readings from one device go unverified, causing far too many false alarms. Conditions easily detected by comparing to multiple readings go unnoticed. Actions that can save lives require clinical staff interpretation and intervention.

The leading effort to build such a connected system is the Integrated Clinical Environment (ICE) standard, ASTM F2761. ICE combines standards. It takes the data definitions and nomenclature from the IEEE 11073 (x73) standard for health informatics. ICE data communications leverage the Data Distribution Service (DDS) standard. ICE then defines control, data logging and supervisory functionality to create a connected, intelligent substrate for smart clinical connected systems.[4] In Figure 3, the supervisor combines oximeter and respirator readings to reduce false alarms and stop drug infusion to prevent overdose. The DDS DataBus connects all the components with appropriate real-time reliable delivery.

DDS is an Internet of Things protocol from the Object Management Group (OMG).[5] While there are several IoT protocols, most focus on delivering device data to the cloud. The DDS DataBus architecture understands and enforces
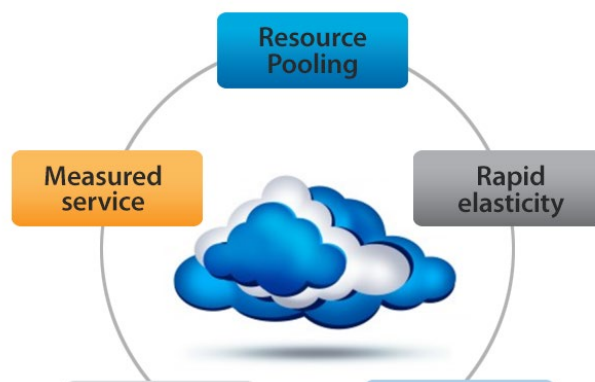

Figure 3. An intelligent Patient Controlled Analgesia system..

correct interaction between participating devices. DDS focuses on the real-time data distribution and control problem. It can also integrate with the cloud, or connect to other protocols to form a complete connected system. Its unique capabilities fit the medical device connectivity problem well.

While the above examples and scenarios are simple, networking medical devices in a clinical environment is quite challenging. Information flow mixes slow data updates with fast waveforms. Delivery timing control is critical. Integration with data from the EMR must provide patient parameters such as allergies and diagnoses. Appropriate monitor readings and treatment history must also be written to the EMR. Large hospitals must match data streams to patients, even as physical location and network transports change during transfers between rooms. Devices from many different manufacturers must be coordinated.

ICE leverages DDS to address these clinical challenges. DDS models the complex array of variables as a simple global data space, easing device integration. Within the data space, the data-centric model elevates programs to exchange the data itself instead of primitive messages. It can sift through thousands of beds and hundreds of thousands of devices to find the right patient, despite moves. DDS is fast and real-time; it easily handles heart waveforms, image data and time-critical emergency alerts.

[3] *Challenges to Implement A Standards Based ICE Platform, Tracy Rausch, Medical Device Interoperability Conference 2013.*

[4] http://mdpnp.org/mdice.html

[5] http://portals.omg.org/dds

Dr. Julian Goldman leads ICE. Dr. Goldman is a practicing anesthesiologist with an appointment at Harvard Medical School. He is also the director of Bioengineering at the Partners hospital chain. His Medical Device Plug-n-Play (MDPnP)[6] project at the Center for Integration of Medicine and Innovative Technology (CIMIT)[7] connects dozens of medical devices together. MDPnP offers a free open-source reference platform for ICE. There are also commercial implementations, including one from a company called DocBox.[8] The CIMIT lab uses these to prototype several realistic scenarios, including the PCA and OR-to-ICU transfer scenarios described here. It demonstrates what is possible with the IoT.

Hospital error today is a critical healthcare problem. Fortunately, the industry is on the verge of a completely new connected implementation. Smart, connected systems can analyze patient conditions from many different perspectives. They can aid intelligent clinical decisions, in real time. These innovations will save lives.

This technology is only one benefit of the exciting future known as the Internet of Things. The IoT will connect many billions of devices together into intelligent systems. It will change every industry, every job and every life. One of the first applications will extend those lives.

[6] http://mdpnp.org

[7] http://cimit.org

[8] http://www.docboxinc.com

ABOUT RTI

Real-Time Innovations (RTI) is the Industrial Internet of Things (IIoT) connectivity company. The RTI Connext® Databus is a software framework that shares information in real time, making applications work together as one, integrated system. It connects across field, fog and cloud. Its reliability, security, performance and scalability are proven in the most demanding industrial systems. Deployed systems include medical devices and imaging; wind, hydro and solar power; autonomous planes, trains and cars; traffic control; Oil and Gas; robotics, ships, and defense.

RTI lives at the intersection of functional artificial intelligence and pervasive networking[SM].

RTI is the largest vendor of products based on the Object Management Group (OMG) Data Distribution Service™ (DDS) standard. RTI is privately held and headquartered in Sunnyvale, Calif.

Download a free 30-day trial of the latest, fully-functional Connext DDS software today: https://www.rti.com/downloads.

Your systems.
Working as one.

CORPORATE HEADQUARTERS

232 E. Java Drive, Sunnyvale, CA 94089
Telephone: +1 (408) 990-7400
Fax: +1 (408) 990-7402
info@rti.com

rti.com

rti_software

rtisoftware

company/rti

connextpodcast

rti_software