Sunderby Hospital in Luleå, Sweden, needed to replace its 12-year-old patient monitors hospital-wide and made the strategic decision to install a new bedside and telemetry monitoring system that used the hospital’s existing wired and wireless IT infrastructure.

ABSTRACT
Sunderby Hospital implemented a new patient monitoring system that runs on the hospital’s existing wired and wireless networks without disrupting clinical workflow or compromising patient safety. They also implemented a real-time location system for telemetry monitors that facilitates fast clinical response in the case of patient emergency.

The objectives of this technical paper are to describe the challenges the hospital faced, best practices for implementing a wired/wireless patient monitoring network, and the benefits the hospital achieved.

BACKGROUND
Norrbotten is the largest and northern-most county in Sweden, comprising one quarter of the country’s land area. Providing healthcare to the county’s 250,000 inhabitants are 5 hospitals, 33 health centers and 34 dental clinics – all of which are connected through a high-speed, redundant, wide area network (WAN).

The infrastructure is centralized at Sunderby Hospital in Luleå, where the data centers, servers, data storage, and staff are located. This arrangement enables central, standardized control of IT and medical technology. All networks in the infrastructure use the same type of network switches, access points, and configuration methods.

The staff of 130 is responsible for:
- Technical infrastructure
- System management of all IT systems
- Maintenance of medical technical equipment
- Support
- Project management

The group has won national and international awards for in-house developed solutions, including VAS, an electronic patient medical record system developed by healthcare professionals for healthcare professionals.
Technical foundation
The county-wide network has high bandwidth and is redundant, with a flat layer 2 network and routed layer 3 network. To avoid network noise, the domains are as small as possible and there is no broadcast communication protocol. The hospital has more than 100 Virtual Local Area Networks (VLANs) in its network.

There are 50 cross-connections located throughout the building and all data-generating equipment is connected to the network. The hospital infrastructure uses Cisco® equipment exclusively for both wired and wireless networks.

The network supports all types of traffic – data, voice, and video – including both wired and wireless IP telephony. To ensure that the network is stable and secure, all equipment connected to the network must be based on open standards so that it can coexist on the same network and be managed by the IT staff.

Important traffic, such as life-critical patient data from Dräger medical devices, is prioritized using Quality of Service (QoS). Dräger patient monitors support the 802.11 b/g standard and WPA2 personal mode encryption.

Goals of the patient monitor upgrade project
– Replace equipment before it was “out of service”
– If possible, use only one vendor for monitoring and anesthesia devices
– Increase quality of care:
  – Ability to monitor patients in “remote wards”
  – Real-time location system for equipment
– Use existing infrastructure, even for telemetry
– Improve work environment for hospital personnel
  – Remove hardware from wards (noise/temperature)
  – Enable wireless monitor to follow patient throughout care path
– Short installation/replacement time
– Have vendor provide project manager

Requirement for Wi-Fi®
Prior to implementing Dräger’s wireless patient monitors, the hospital had a monitoring solution that used the existing wired network.

A key requirement for the new monitoring system was that it use Wi-Fi and run on the hospital’s existing network. This requirement was based on the IT staff’s experience with another hospital in the county-wide network, which had a proprietary wireless network managed by the equipment vendor. Data from that network needed to be stored in the county network and the IT staff had experienced some problems with that proprietary implementation. As a result, the IT department wanted the new monitoring equipment to run on the hospital network.
The hospital was already using its wireless network for data, video and voice (IP telephony) and guest access. Prior to the installation of the new monitors, the only medical devices that used the Wi-Fi network were EKG equipment, mobile video conferencing equipment for remote consultations, and ambulance computers.

The hospital considered different monitoring solutions, but Dräger was the only vendor that was able to show successful installations where patient monitors run on the existing hospital network. Dräger monitors are designed to run on Infinity® OneNet, a network design that allows hospitals to safely and securely move life-critical patient data on the existing wired and wireless network. This approach saves the expense of building and maintaining a separate patient monitoring network. The Dräger Infinity M300 patient-worn (telemetry) monitor uses verified standards (802.11 b/g) and has official Wi-Fi certification.

**Security and reliability**

Given that the hospital network is actually a government network, the IT department has to comply with a variety of legal requirements. The Norrbotten network is inspected on regular basis and the IT staff constantly improves on its reliability. The first priority is the security of patient information, which means that no data is lost and that all information must be instantly available. The network must also meet patient privacy requirements. Because the IT department owns the network, it decides which type of equipment and traffic are allowed on the network. The IT department had no reliability concerns about implementing Wi-Fi based monitoring because the network had long proven itself reliable for the transfer of critical data. It was designed and built for high reliability, high availability, and hospital-wide coverage. The network is constantly monitored and all components at the core infrastructure are redundant. Because the network is used 24/7/365, the hospital has service agreements to secure quick recovery in the event of hardware issues.

Before the installation of the patient monitoring solution, Dräger’s network experts conducted a site survey to inspect the network and verify the prioritization of transmitting patient data. The IT department only needed to make minor adjustments regarding signal strength and the network was approved for the use of life-critical medical devices.

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**Installation at-a-glance**

- 4 Infinity Gateway Servers
- 3 Infinity Symphony Servers
- 18 Infinity CentralStation workstations
- 175 Infinity Acute Care System monitors
- 25 Infinity M300 patient-worn monitors
- 1 Gateway Server and 1 Symphony Server for each of two other hospitals in the Norrbotten network; Gateway Servers require routed multicast, achieved with layer 3 between the very remote locations (Piteå and Kiruna).
Patient transport, connectivity and configurability at Sunderby Hospital with the Infinity® Acute Care System

### EMERGENCY ROOM
- Patient is admitted
- Monitoring profile of the ER is loaded on Infinity® Acute Care System
- Trends, events and ST complexes are stored

### INDUCTION AREA
- Infinity® M540 is docked
- The Induction profile replaces the one from the ER automatically
- Data is stored continually without interruption

### INTENSIVE CARE
- Infinity® M540 is docked
- The ICU profile replaces the OR profile automatically
- Trends are retrieved from the Cockpit at the anesthesia device
- Data is stored continually without interruption
- Trends from the ventilator are stored and displayed on the Cockpit

### OPERATING ROOM
- Infinity® M540 is docked
- The OR profile replaces the one from induction automatically
- Data is stored continually without interruption
- Trends from the anesthesia device are stored and displayed on the Medical Cockpit®

Hospital-wide implementation of Pick and Go technology streamlines clinical workflow and helps increase patient safety by providing continuous monitoring and data collection.
MEETING THE CLINICAL NEED
Bedside/transport and telemetry monitors
For bedside/transport monitoring, Sunderby Hospital chose the Infinity Acute Care System, a hospital-wide solution that includes an Infinity M540 monitor for bedside and transport, and a companion Medical Cockpit® workstation that brings networked patient data to the point of care via a standard built-in computer for Citrix® and Web clients. The Dräger solution also included the Infinity M300, a patient-worn monitor that uses industry-standard Wi-Fi technology for transmitting data.

Because patients on a single ward have different acuity levels, the clinical staff wanted to meet the needs of all patients wherever they are located. This included allowing telemetry patients to move about certain areas of the hospital to increase mobility. Infinity M300 monitors enable this mobility because they monitor patients locally – through built-in processing, alarming, and a display – and continually send real-time data to the Infinity CentralStation using the hospital’s Wi-Fi network.

For bedside and transport monitoring, the hospital can now quickly deploy an Infinity M540 monitor to any patient, on any ward, wherever needed. As a result, patients don’t have to be relocated to be monitored appropriately or wait for a bed in another ward. Central monitoring begins automatically as soon as patients are admitted, and the nursing staff can see the vital information of each monitored patient at the central station, regardless of their location.

Rather than each department maintaining its own equipment inventory, monitors are now inventoried by the hospital and shared across departments.

Because of Dräger’s Pick and Go® technology, the same Infinity M540 monitor can stay with the patient throughout their stay, eliminating the need for a separate transport monitor and saving time spent disconnecting and reconnecting patient cables. The monitor automatically adopts a new monitoring profile customized for each new care area. This streamlines clinical workflow and helps increase patient safety by providing continuous monitoring and data collection.

Built-in safety
The IT team implemented Network Admission Control (NAC) on the network, which enables them to recognize any device by its MAC address. This means that only known and trusted devices can connect to the network; others will be rejected. This improves safety and security in a medical environment.

As a result, it is now possible for the clinical staff to connect a patient monitor to any available network outlet. When the network detects the device, it automatically maps the patient monitor to the correct virtual LAN (VLAN). This gives clinicians a high level of flexibility in using the monitors in any room throughout the hospital.

Telemetry and Real-Time Location System
It was very important to Sunderby Hospital that the patient monitoring system could be integrated with commercial and custom third-party solutions. For example, AeroScout® real-time location software is integrated with Infinity M300 patient-worn monitors and Infinity OneNet – the Dräger networking solution that enables patient monitoring data to safely move on the hospital’s existing wired and wireless infrastructure.
Real-time location system

Integration between the Infinity® M300 telemetry monitor and AeroScout® real-time location software enables staff to determine the location of ambulatory patients for immediate response in case of an alarm event.
Now, if an M300 patient has an alarm event, clinicians are instantly notified of the alarm details and the location of the patient monitor within 2 meters (6.56 feet). This facilitates rapid response with appropriate clinical resources should a life-threatening event occur. As a result, patients benefit from increased mobility without their safety being compromised.

The AeroScout-Dräger device integration offers many benefits over using a pager interface. This integration facilitates the high-level WinAccess API on the Infinity Gateway, so all information is transferred in real time. Because the interface is bi-directional, alarms can be transmitted. Patient names and admitted monitors are transferred automatically. If a new patient is admitted with an M300 monitor, the AeroScout configuration runs automatically and the new patient will immediately show up in the AeroScout MobileView screen. In addition, because it is a high-level interface, it is open for future enhancements.

**Implementation**

While this was a very complex project, careful project management minimized disruption to the clinical workflow. Because of the close working relationship between Dräger and Sunderby Hospital, and the detailed planning that went into the implementation, the actual switchover from the old monitoring system to the new was accomplished with all patients in the ward and took less than one day, with minimal patient disruption.

This fast implementation was possible because each monitoring system had been preconfigured and tested at the Dräger Customization Center in Lübeck, Germany. As a result, the monitoring system had only to be unpacked at the bedside, connected, and it worked properly from the first moment.
have an effect on a patient if something happens to them are classified today as medico-technical products. This means that these worlds, completely unavoidably, have approached each other and must merge together. We realized this five or six years ago when we organized our IT operations.

We had to build an organization that matches the demands of the future, and then we moved close to each other, physically closer. We have one manager for both sides, we have common projects, quality groups, joint case management systems, joint support, and we are trying to teach each other, learn the culture, history and the specialties that either side is good at, in order to combine our operations in a good way. And that’s the key to being able to cope with future demands for medico-technical information systems.

A common vision
If you are faced with a project of this caliber, it is important that IT and biomedical engineering work together, that you have joint control, that you have the same vision, and that you work with the skills and specialists to achieve the best results together with your supplier. When it comes to collaborating on a large project, it is important that suppliers clearly understand where healthcare is going. In the future, healthcare personnel are going to be a lot more mobile in their work. We are going to have wireless networking everywhere, and equipment, patients, beds, and wheelchairs are going to be rolling around everywhere, and you want to be keeping track of everything. Then it will be a requirement to interact just as we have done on this project, on infrastructure, on the IT side, and on medico-technical products.

The healthcare personnel of the future are going to have a handset for as much as possible. You don’t want to have mobile phones, alarms, pagers, computers, monitors, and to have to be pressing buttons on all these devices. You have to work toward an integrated and mobile workplace in healthcare.

KRISTINA JONSSON, CIO
On strategy
If you are using an existing infrastructure to connect medical devices of any kind, you have opportunities in the future to actually combine these specialties with various devices and equipment. You also have opportunities that only exist when you actually use the IT infrastructure. We understand that this is pioneering the future – bringing IT and medical technology together in this way – and we want to continue working in this manner. This is a strategic choice we are making.

Uniting IT and biomedical engineering
Viewed in a traditional manner, IT and biomedical engineers usually work on two completely different tracks, and have always done so for as long as we have been around in our different orientations. What we have seen over the last five years is that IT and medical technology are growing together more and more.

Medico-technical products
We have to work together on what is now called medico-technical products – which are medical records and healthcare systems, for example. All systems that can
The single network advantage
When it came to patient monitoring, the IT department couldn’t set functionality requirements: That was up to the healthcare professionals. The only requirement we had was that the patient monitoring system could run on our existing infrastructure, whether wired or wireless.

There are many advantages to having just one network, but the biggest advantage in my opinion is that we can effectively manage it. We can put all our knowledge, energy and resources into making it work in the best manner possible. Having multiple networks would require more time and more resources – both human and financial. If you have multiple parallel wireless networks, there is a risk that they will interfere with each other. You create problems for yourself quite simply.

Mitigating risk
Some people may feel that there are risks associated with running medical equipment and patient monitoring on the existing IT network, and ask “Is it safe enough?” and “Are you managing it according to the specified requirements?” The answer is “Yes.”

Now that we are running the new patient monitoring system on our existing networks, both wired and wireless, it’s now a medical-grade network. This places demands on us in terms of how we manage the network, so we have to manage it in accordance with the requirements of the medical manufacturers.

Scalability for the future
It is fantastic that the solution is scalable. We can take advantage of the configuration work we have already done and the lessons we have learned. If we implement the same patient monitoring equipment at other hospitals, we simply have to scale out the solution. That saves both time and money.

Security requirements
We have to take into consideration many different kinds of security, such as patient safety, patient privacy, and pure IT security, etc. The network is built with high fix wrap security. Through Quality of Service, we ensure that time-critical data are prioritized over other less prioritized traffic, whether transferred in the wireless or the wired network.

One good thing with this solution is that there are never any problems when we want to secure our environment or make changes. If we want to apply security updates to a server in the monitoring solution, we ask Dräger if it is okay and we always get a positive answer. That is very important! We have solutions from other vendors and it is impossible for us to keep their solutions secure. I wish all vendors of medical systems behaved like Dräger.

Experience matters
It was very valuable to us that Dräger has many years of experience in installing patient monitoring at various hospitals around the world. By working closely with Dräger’s engineers, we were able to have our environment approved to run this system. There were very few changes that had to be made, just minor adjustments to power levels in the wireless network, etc. It felt good to get a stamp of quality on the network, even before installation began.
STAFFAN KIHLBERG, ASSISTANT PROJECT MANAGER

Meeting the biggest challenge

The biggest challenge of this project was to install a new monitoring system and replace the old one without interfering with patients. To avoid disrupting the clinical workflow and patients, we first did a test setup where we installed and tested the entire infrastructure of the hospital.

As soon as that was finished, Dräger planned the installation and everything came preconfigured. We installed the system department by department and informed them well in advance. The only thing we did when going to the department was to replace the existing equipment with the new one.

Regarding the actual installation, we implemented several units at a time in two-week time segments. During the first week, we did a pre-installation outside the department, where we set up all the equipment to verify that it worked and Dräger provided application training. Then in week two, we did the installation inside the department, during which the department received application support from Dräger.

HENRIK VESTERLUND, IT ENGINEER

Avoiding interference

We optimize our Wi-Fi network by, among other things, separating traffic on separate SSIDs and VLANs to make sure the data does not interfere with each other. We probably have about 100 VLANs at our hospital and six or seven SSIDs that we publish. We had no problem giving Dräger their own SSID to be able to use for their equipment. We separate data traffic into a separate VLAN to make sure that the data from Dräger’s medical equipment can coexist with traffic from other equipment without there being any interference.

Third-party integration

It’s a great advantage that Dräger’s patient monitoring system facilitates integration with other systems. For example, the AeroScout real-time location system improves patient safety by enabling clinical staff to quickly find a person who requires help in an emergency situation, regardless of where they may be in the hospital.
Dräger has a Customization Center in Europe that configures and tests the actual equipment, so when it came to us it was ready plug in and run properly. Because the equipment came preconfigured, it facilitated a much faster installation with much less setup time and disruption than otherwise would have been possible.

Lessons learned
The project went very well; people were competent, both from Dräger and from our side. We jointly solved any problems that arose along the way.

If I were to give advice to another hospital that was about to carry out a similar project, I would advise them to plan very carefully in collaboration with the supplier. I would also suggest testing the system in place before the actual installation to verify that everything works, in advance. And also to inform everyone on the clinical side what is about to happen and when.

CONCLUSION
In summary, the key success factors of this project were:

- Central control of the infrastructure: a single solution for the entire county
- Close cooperation between top management, end users, IT and biomedical technology staff, and suppliers
- Having IT and biomedical engineers in same organization working closely together
- A systematic approach to system management, development and user training
- End user focus