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Solution Blueprint  
Internet of Things

# CAPTURING ELECTRONIC MEDICAL RECORDS WITH THE INTERNET OF THINGS (IOT)

NEXCOM\* USES INTEL® IOT GATEWAY SOFTWARE TO DELIVER A MEDICAL INFORMATICS SOLUTION THAT CONNECTS MEDICAL DEVICES TO A PRIVATE CLOUD.

## Executive Summary

The need to cut cost, improve medical care, and adopt electronic medical records (EMR) is driving hospitals to implement information technology (IT) solutions that streamline procedures such as billing, medical imaging, and electronic medical records processing. These solutions exemplify the convergence of healthcare and IT systems, an evolving field known as medical informatics. However, innovation is often impeded by the many medical devices, for example dialysis machines, that are stand-alone and unconnected, and unable to share data with IT systems without manual intervention.

Helping overcome communication barriers between medical devices and IT networks, NEXCOM\* developed a medical informatics solution based on technologies from

the Internet of Things (IoT). The solution turns medical device data into electronic medical records (EMR) and sends them to the hospital's private cloud, where data analytics can be performed to better evaluate a patient's condition.

The solution has been implemented in a hospital located in Nanjing, capital city of China's Jiangsu province. With assistance from NEXCOM and Suntop\*, a medical device supplier with extensive experience in the dialysis market, the hospital is able to increase staff efficiency, improve medical care, support EMRs, and enable patient data sharing among medical providers. This paper describes how medical equipment manufacturers, retailers, systems integrators, and hospitals can deploy this world-class, end-to-end IoT solution.

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## Key Business Objectives

Increase medical device connectivity, reduce healthcare cost, and improve patient outcomes, thus making medical care more affordable and effective.

## Business Challenges

Sharable electronic medical records (EMRs) clearly provide many benefits to healthcare providers and patients, but this can be a challenging undertaking. Hindering this effort are medical devices that use proprietary communications protocols and therefore cannot send clinical data over Internet Protocol (IP) to a server on a healthcare IT network. As a result, many healthcare facilities have “islands” of data that cannot be shared and stored in a centralized data base unless someone re-enters the data by hand.

## Solution Benefits

For a long time, NEXCOM has been working on medical informatics solutions by developing IoT gateways, networking, and cloud computing related technologies. The IoT gateway connects to medical devices using their proprietary communications protocol, and then collects and filters the clinical data before sending it to a server on the IT network. Once the data is captured by the hospital's private cloud, data analytics can be performed to better evaluate patient conditions and automate healthcare processes. Data sharing opens all types of opportunities, such as:

- **Increase Staff Efficiency**

Before the NEXCOM solution was deployed, nurses and doctors had to make sure patients followed instructions during the dialysis process: from registration and measurement to the end of the treatment. All these procedures were done manually, which consumed a significant amount of staff time. The solution automates the process by providing patients with RFID cards so they can complete the registration and measurement

processes by themselves, thereby giving staff more time for other activities. In addition, it allows more frequent and faster data updates, which improves workflow efficiency and minimizes human data entry errors.

- **Improve Medical Care**

Previously, dialysis data could only be viewed on a display terminal located at the patient's bedside, so it was not possible to carefully monitor multiple patients at the same time. With NEXCOM's solution, doctors and nurses can remotely monitor all the patients on a computer display or a wireless medical tablet, making it much easier to track patient status. The solution not only enhances clinical analytics capabilities and decision support, but it is also central to providing a more accurate and complete picture of a patient's condition.

- **Support Electronic Medical Records (EMRs)**

Since the dialysis equipment was not connected to the hospital's IT network, treatment data had to be written down on paper and stored in folders. The NEXCOM solution makes the process paperless by connecting the dialysis equipment to servers that collect and consolidate clinical data. This process change is consistent with efforts by the National Development and Reform Commission (NDRC) of the People's Republic of China to encourage paperless processes across a wide range of industries, including healthcare.

- **Enable Patient Data Sharing**

Before the hospital implemented the NEXCOM solution, patients could not have their dialysis data transferred to other facilities, making it very difficult to get treatment at another location. Now, patient data is stored in a private cloud, so any facility in a healthcare provider's network can access the data and treat patients.

## Solution Overview

This NEXCOM medical informatics solution uses emerging technologies like IoT, cloud computing, and big data analytics to enable new IT services for the healthcare industry. It connects medical devices to healthcare IT networks so data can flow seamlessly across healthcare facilities. The concepts from this dialysis solution can be applied whenever there is a need to collect, store, and analyze data from medical devices.

**Solution Support**

NEXCOM provides the hardware and software components, which the company tests and certifies prior to delivery and installation by NEXCOM engineers at the hospital. Since the solution is based on IoT technology, NEXCOM can customize the software as needed by the hospital. The solution also simultaneously supports dialysis machines from different equipment manufacturers.

**Solution Capabilities**

Figure 1 shows a high-level IoT architecture that connects the different medical devices to a private cloud in a healthcare facility. To begin the process, the patient carries an RFID card containing personalized information, which is read by the RFID reader and sent to NEXCOM gateways that are connected to medical devices: a scale, a blood pressure monitor, and a dialysis machine. The gateways collect and process data from medical devices before sending it to a NEXCOM Wi-Fi Access Point (AP).

Doctors and nurses can interact with the medical devices using a desktop manager and medical tablet that access the wireless access point. Applications include: enter patient data; set up device; schedule dialysis; synchronize data; and manage patient and clinical data.

The wireless access point communicates with the IT server via a router, firewall, and switch. The server (and the backup server) runs dialysis manager software, called HAS FC 365, that records and backs up patient and dialysis data.

**Results**

With NEXCOM's solution, patients were able to complete the registration and measurement process automatically using RFID cards. All the data collected from the dialysis machines was transferred to a central server through Ethernet, allowing doctors and nurses to monitor patients' status remotely on the computer display. In addition, the solution displayed much more information (e.g., medicine records) than the dialysis machine's original user interface, thus providing a more comprehensive view of patient status.

At patients' beds, doctors and nurses could also monitor the patients' conditions with medical tablets connected to the network. NEXCOM's solution not only helped the hospital minimize the cost and effort in maintaining a dialysis center but also improved the quality of medical care.

**Technology**

This section describes the key IoT, cloud computing, and big data analytics technologies employed by the NEXCOM medical informatics solution.

- **NEXCOM Gateway NIO 100** (Figure 2) is a compact and easy-to-use device specially developed to bridge the communication gap between medical devices and the healthcare IT domain. The NIO 100 collects clinical data from a wide range of medical devices via proprietary or standard serial protocols, such as RS232/485/DIO, and transmits the data to the cloud via 3G, Wi-Fi, or Ethernet networks. Designed as an IoT gateway for cloud applications, it can also consolidate and perform preliminary analysis on clinical data.

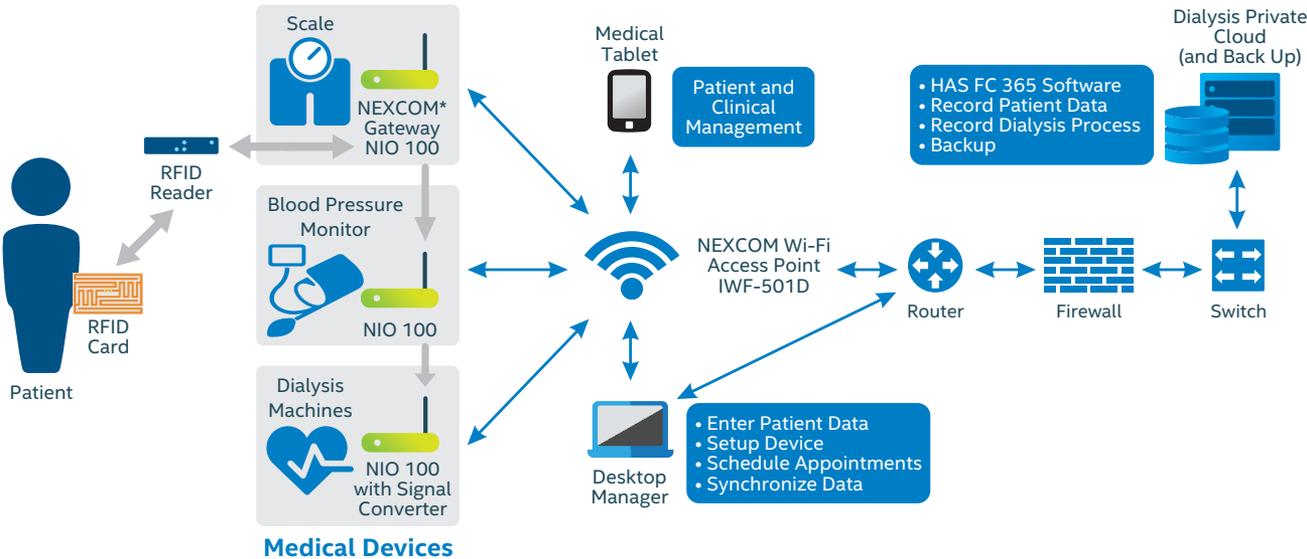


Figure 1. Simplified Architecture Connecting Medical Devices to the Healthcare IT Network

## Capturing Electronic Medical Records with the Internet of Things (IoT)



Figure 2. NEXCOM\* Gateway NIO 100

The gateway features the [Intel® Quark™ SoC X1000](#) and the [Intel® IoT Gateway](#) software stack that has various manageability, security, and connectivity components:

**Manageability:** OMA DM, TR-069, Web-based configuration interfaces, runtime, environment, Lua\*, Java\*, and OSGi\*.

**Security<sup>1</sup>:** McAfee Embedded Control, Open SSL library, SRM signing tool, certificate management, secure boot, application integrity monitor, application resource control, secure package management, and encrypted storage.

**Connectivity:** ZigBee\*<sup>2</sup>, cellular 2G/3G/4G, Bluetooth\*, serial, USB, VPN, Wi-Fi Access Point, and MQTT.

The software stack runs on Wind River\* Linux\* and is supported by the Wind River Development Environment.

- The [NEXCOM Wi-Fi Access Point IWF-501D](#) supports 802.11b/g/n, operating in the 2.4 GHz band. Pictured in Figure 3, it has a built-in dual-polarity antenna and detachable SMA connectors with dual Ethernet ports, and supports passive 24 VDC Power over Ethernet (PoE), allowing for easy installation without any environment limitations.
- The desktop manager combines the highly-reliable, fanless [NISE 3640E](#), a PC based on the Intel® Core™ i7 processor, and NEXCOM HAS FC 365 software. The software performs a comprehensive set of dialysis automation functions, as shown in Table 1.
- The healthcare server is the NEXCOM HAS FC 365 Server with two high-performance Intel® Xeon® processor E5-2600 product family. RAID 10 is also supported to provide data redundancy.



Figure 3. NEXCOM\* Wi-Fi Access Point IWF-501D

NEXCOM* HAS FC 365 Desktop Software	
Patient Data Management	<ul style="list-style-type: none"> <li>• Build and manage patient data</li> <li>• Create medical records</li> </ul>
Dialysis Scheduling	<ul style="list-style-type: none"> <li>• Schedule normal and emergency dialysis</li> <li>• Change schedules</li> </ul>
Dialysis Process Record	<ul style="list-style-type: none"> <li>• Record process, dialysis, and physical data</li> </ul>
Doctor's Advice	<ul style="list-style-type: none"> <li>• Record regular and temporary advice</li> <li>• Record start and end of treatment</li> </ul>
Material Stock System	<ul style="list-style-type: none"> <li>• Generate statistics on material usage</li> <li>• Manage materials in the warehouse</li> </ul>
Medical Treatment Process	<ul style="list-style-type: none"> <li>• Record medical statistics and laboratory results</li> <li>• Synchronize data with Laboratory Information System (LIS)</li> </ul>
NEXCOM HAS FC 365 Tablet Software	
Patient Daily Scheduling and Status	<ul style="list-style-type: none"> <li>• Schedule patient daily appointments</li> <li>• Track dialysis and physical status</li> </ul>
Patient Dialysis Data	<ul style="list-style-type: none"> <li>• Record personal and dialysis data</li> <li>• Record doctor's advice and treatment</li> </ul>
Dialysis Process Record	<ul style="list-style-type: none"> <li>• Record clinical data (e.g., blood pressure) during dialysis</li> <li>• Record patient's status</li> </ul>
Doctor's Advice	<ul style="list-style-type: none"> <li>• Record regular and temporary advice</li> <li>• Record start and end of treatment</li> </ul>

Table 1. Capabilities of NEXCOM\* Desktop and Tablet HAS FC 365 Software

## Capturing Electronic Medical Records with the Internet of Things (IoT)

### Summary

Using its extensive healthcare and IT experience, NEXCOM developed a robust medical informatics solution for hospitals. In particular, this dialysis automation system combines NEXCOM and Intel expertise in IoT, cloud computing, and data analytics to connect medical devices to a healthcare IT network. The result is that improved data sharing throughout a healthcare facility can help increase staff efficiency, improve medical care, support EMRs, and enable patient data sharing among medical providers.

### Resources

#### Intel® Internet of Things Solutions Alliance

Members of the Intel® Internet of Things Solutions Alliance provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT.

#### Intel® IoT Gateway Development Kits

Intel® IoT Gateway development kits enable solution providers to quickly develop, prototype, and deploy intelligent gateways. Available for purchase from several vendors, the kits also maintain interoperability between new intelligent infrastructure and legacy systems, including sensors and data center servers.

For more information about the NEXCOM solutions for the healthcare industry, visit <http://www.nexcom.com/applications/DetailByDivision/medical-computer>.

For more information about Intel® solutions for IoT, visit [www.intel.com/iot](http://www.intel.com/iot).

<sup>1</sup> No computer system can provide absolute security. Requires an enabled Intel® processor, enabled chipset, firmware, software and may require a subscription with a capable service provider (may not be available in all countries). Intel assumes no liability for lost or stolen data and/or systems or any other damages resulting thereof. Consult your system or service provider for availability and functionality. For more information, visit <http://www.intel.com/go/anti-theft>.

Consult your system manufacturer and/or software vendor for more information.

<sup>2</sup> Enabled by third-party hardware.