



Solving Healthcare Problems by Solving Problems for the Internet of Healthcare Things

IMPROVING HEALTHCARE EFFICIENCY, COST, AND QUALITY

One of the most remarkable changes in healthcare of late has been in pay practices. The Affordable Care Act of 2010 and other policies include a number of provisions designed to encourage improvements in the quality of care. Before pay-for-performance initiatives were enacted, providers were paid anytime they saw a patient, regardless if they did a poor job or a good job. Now they are being held accountable for the care they deliver, with rewards for high quality and high efficiency, penalties for poor quality and inefficiency.

From a 2014 Commonwealth Fund report¹ that ranks the US healthcare system last among 11 countries, examples of inefficiency include:

- Time and dollars spent dealing with insurance administration
- Lack of communication among health care providers
- Duplicative medical testing

In terms of cost, the report states that the US stands out for having the highest costs and lowest performance, spending \$8,508 per person on healthcare in 2011, compared with \$3,406 in the United Kingdom, which ranked first overall.

And in terms of healthcare quality, the US ranks in the middle. On two of four measures of quality—effective care and patient-centered care—the U.S. ranks near the top (third and fourth of 11 countries, respectively), but it does not perform as well providing safe or coordinated care.

¹ K. Davis, K. Stremikis, C. Schoen, and D. Squires, *Mirror, Mirror on the Wall*, 2014 Update: How the U.S. Health Care System Compares Internationally, The Commonwealth Fund, June 2014.
<http://www.commonwealthfund.org/publications/fund-reports/2014/jun/mirror-mirror>

A FEW HEALTH-RELATED MEMBERS OF THE INTERNET OF THINGS

- CT scanners
- Defibrillators
- Electronic pill dispensers
- Fitness bands and other trackers
- In-home blood glucose/heart monitors
- MRI machines
- Nanotechnology
- Smart prescription bottles
- Smart scales
- Smart watches (alerts, reminders, schedules)

“The nice thing about standards is that you have so many to choose from.”

— Andrew S. Tanenbaum
Professor of Computer Science at Vrije Universiteit (Amsterdam) and author of several books on computer networks and operating systems

Analyzing information collected from medical devices connected to the Internet of Things (IoT) in real time will improve efficiency, cost, and quality. Information provided by the IoT will also help manage the health of entire populations. Data from electronic medical records and imaging and monitoring equipment will improve and speed medical decision-making, coordination, and administration. In addition, it will enable patients to take a more active role in managing their health.

But, even with all these problem-solving benefits, healthcare always takes a cautious approach to adopting technologies, and the IoT will be no different. Many aspects of the Internet of Healthcare Things (IoHT) will require regulatory oversight, such as for ensuring that the technology infrastructure is adequate to both support traffic volume and protect privacy.

This paper explains how the TIBCO Fast Data platform is not only the optimum solution, but advanced enough to begin improving healthcare efficiency, cost, and quality now, by solving problems for the IoT.

ALLEVIATING DATA OVERLOAD

While most companies serving the IoT market focus on developing devices that capture data and push it to the cloud, TIBCO focuses on providing systems that receive, process, analyze, and act on all that data (through automated system and process management). Examples of actions that could be taken:

- Automated billing, alerting, and messaging to improve insurance administration
- Automated (and therefore more complete and timely) communication and coordination among health care providers
- Automated checks of prior medical testing and automated delivery of results to parties attempting to reorder tests (avoiding duplication)

These are just three examples. TIBCO technologies provide all capabilities needed to support real-time big data IoT processing and privacy protection.

ADDRESSING HARD CHALLENGES

Despite the rapid growth of the IoT, there are no universally adopted standards. Device manufacturers and service providers do not use common transport methods, protocols, or interfaces. Because devices may not speak the same language, most IoT solutions have difficulty scaling.

Due to low-processing capabilities and low-voltage requirements, and the enormous number of devices expected to be connected to the Internet over the next few years, many IoT specialists believe that IoT communication will be via local hubs, electronic gateways that mediate protocols and technologies among devices. Regardless of how devices communicate with each other, TIBCO technologies are hardware agnostic. The TIBCO Fast Data platform, built using common standards and technologies, solve many architectural, data overload, and processing problems:

A COMMON LANGUAGE

Even though organizations such as the Continua Health Alliance, a participant of the International Organization for Standardization (ISO), as well as the Institute of Electrical and Electronics Engineers (IEEE), are working to establish standards for healthcare solutions, not all devices will have the capacity to speak the same language. The problem will likely be not a lack of standards, but too many—and disagreement over which initiative to pursue. A Google search on “IoT protocols” shows the complexity and differing opinions on how to pass data from physical devices through networks to applications.

However, TIBCO integration technologies offer hundreds of adapters for creating connections, for easily and quickly onboarding new devices, and for providing interoperability without sacrificing performance or functionality. The TIBCO Fast Data Platform comprised of integration, event processing, analytics, and other technologies, is not a standard, but a method that allows many standards to be seamlessly used to provide the right data—even from the huge volumes being generated by the IoT and other sources—and deliver it to the right people and systems at the right time.

TIBCO adapters provide connectivity to IoT device data and applications as well as to other applications, systems, and services. You can aggregate and quickly analyze data from many, many sources, which is a requirement for providing accurate health assessments.

WORKLOAD SHARING

All the processing of data aggregated from hundreds—or even hundreds of thousands—of sensors, devices, applications, and services, can be performed by the TIBCO platform running on high-end servers or even on some commodity hardware.

The high-speed TIBCO in-memory architecture (marshalling the combined memory of local servers) ensures rapid response and low latency for IoT networks. TIBCO Fast Data applications are architected end-to-end using in-memory computing, which allows for high-speed retrieval and processing of all your big data. The in-memory architecture also acts as a bridge between real-time streaming analytics needed for monitoring data and the slower-to-access warehoused data, such as patient identity and medical history.

OPERATIONAL VISIBILITY

While more and more devices are being interconnected, none have the storage capacity or processing power to maintain context of a single patient, much less track a group of patients (patients having the same symptoms, diagnosis, and treatment). As new devices, data, and applications are added, fragmentation will make it difficult to keep track of processes end-to-end.

For example, data from monitoring systems for heart rate, pulse rate, blood oxygen, blood pressure, glucose, respiration, air flow, head movement and position, snoring levels, skin temperature, medication dosage and dispensing times, electronic patient responses, and others, all need to be assigned to the right patient, along with the time the data was recorded. Electronic health records (EHR) systems need to be updated, and analysis of the data automated so that nurses or doctors are alerted at the right time for follow up—and not before.

The TIBCO Fast Data platform solves fragmentation with event processing state machines, a powerful tool for tracking and tracing the end-to-end lifecycles of discrete “concepts,” data structures that can be used to represent an entity (such as a patient) whose state needs to be maintained over time for event correlation (events such as “heart rate + date + time.”)

State machines can monitor for missing events and raise alerts in real time while maintaining complete auditability. They can also generate events that can be sent through the Fast Data platform to update a dashboard or an EHR system, for example. For a state machine that performs multiple transactions, rules can be used to determine the correct transitions.

Use of TIBCO event processing state machines provides complete, real-time operational visibility.

IOT PLUMBING BEST PRACTICES 1

- 1 Internetworking. Reduce the distance between devices and data processing to reduce latency and ensure continued service in the event of an Internet-connection outage. Most organizations will install an on-premise IoT system that communicates with a cloud-based solution for extended coverage, analytics, and processing. In addition, keep your IoT networks separate from other networks (i.e. faculty, patient, and guest-accessible WiFi networks) to provide an added layer of security, reduce traffic, and enhance performance and reliability.
- 2 Continuous monitoring. Continuously conduct risk assessments of your IoT network and infrastructure. Connecting any (and many) devices to your network and to the Internet can open a lot of security holes. Not only monitor the devices, but also what data is moving outside of your firewall. In other words, perform the same network audits on your IoT infrastructure as you would your enterprise infrastructure.

TIBCO log management products support compliance without complexity, letting you monitor enterprise activity and risk, manage and review network policies according to mandates and regulations, address vulnerabilities, protect against attacks, and demonstrate compliance.

MASTER DATA MANAGEMENT

Keeping multiple copies of the same data in sync across all locations is a challenge. Master data management ensures that all of your data is stored and referenced from a single location, providing a reliable source of the truth that will always be up-to-date.

HISTORICAL AND REAL-TIME ANALYTICS

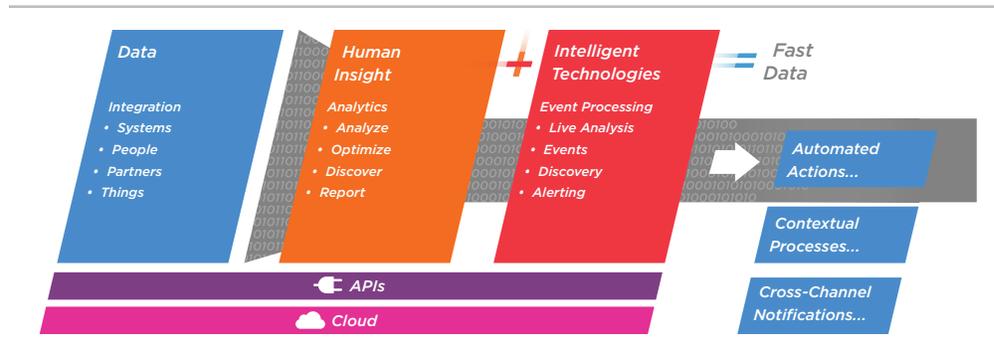
Many companies in the IoT space today offer analytics of historical data. However, only a few offer real-time analytics. TIBCO data visualization and analytics software, and push-based, real-time analytics dashboard, supply historical and real-time data analytics. This combination allows healthcare providers to determine the prognosis for patients based on what is happening this second, as well as on their health history over an extended period, providing more context and a more fully informed diagnosis.

AUTOMATED ACTION

Unlike many systems that can only raise alerts based on the current state of data, TIBCO technologies can analyze based on predetermined patterns and rules, and invoke support systems to take automated action: initiate a workflow, place an order, update a record. These types of processes can be performed without human intervention, errors, and constraints, such as absence, fatigue, and dependability. Automated tasks can be completed faster and completion automatically confirmed.

FULLY ADAPTABLE AND FUTURE PROOFED

As your needs change, the Fast Data architecture can adapt to support new data processing requirements, whatever they may be.



The TIBCO Fast Data Architecture: Components include integration of real-time streaming data, machine analytics (including event processing software), human intelligence (and analytics software), an in-memory architecture, Master Data Management applied to big data stores, and automated actions throughout the process.

IOT PLUMBING BEST PRACTICES 2

- 3 Test and audit. Before connecting any device to your IoT infrastructure, first install and test it in a sandboxed environment where only outgoing requests are possible. Determine which external systems your devices are communicating with and what data is being transmitted between them. Make sure the device is capable of supporting encrypted data on its way out as well. Also, perform an audit to see what ports (if any) your devices are listening on for incoming requests and plug holes as necessary.
- 4 Maintenance. Check with the vendors of your IoT devices to ensure that devices have a secure mechanism for updating firmware remotely. Not only will this save time for your technicians, it will also reduce downtime and help ensure reliability.

HOW FAST DATA WORKS IN HEALTHCARE

This Fast Data architecture is born from over 20 years of innovation. It supplies one unified solution that helps you integrate all your data, analyze it to gain insight, scan for events that require action, act, and continue to learn and improve.

INTELLIGENT TECHNOLOGIES

Fast Data is big data in motion, all of a hospital's data that can be generated at incredible speeds and volumes, at sample rates of thousands or tens of thousands of times (or more) per second. Fast Data is time-critical, existing within a small window of opportunity where it identifies and correlates with other data and kicks off an action or decision based on the events identified and the analytics applied. When this data is received through the integration bus, it is passed to an event processing engine where human-written rules are applied that trigger action. It can also be sent on to TIBCO® MDM for long-term storage and reference, or it may run through streaming analytics that can apply decisions in real time. Streaming analytics can invoke automation, like rescheduling patients and doctors when an operating room opens up. To make a decision like this automatically, when the system sees the "O.R. schedule change" event, it checks against prewritten rules. The rule may start a workflow that coordinates the rescheduling. The architecture creates a kind of IT nervous system that can sense and respond in real-time to issues, even those that last only a few seconds or minutes.

HUMAN INSIGHT

Analyzing data at rest can bring insight. Data scientists can analyze historical data for important predictive signals. For example, correlating events may reveal patterns that show that patients with similar symptoms need different treatments depending on their age, gender, and health history. Once this knowledge is discovered and deployed into the system, you have gone full circle, turning insight into action.

Real-time streaming analytics is also a tool for applying human insight. It allows even non-technical staff to ask questions and run continuous queries millions or billions of times a day against each and every event in the stream. When conditions change, the results are updated to users.

The implications for healthcare are greater than operational efficiencies and cost savings. One Midwest hospital is looking for precursors to heart attacks. Another is analyzing real-time patient data to accelerate diagnosis and treatment of COPD and congestive heart failure.

With the Fast Data platform, users avoid data overload, act on what they see, and override automated action at any time. For example, a doctor can monitor a patient's intravenous therapy (or receive alerts based on a threshold) and make adjustments to their medication or dosage, pushing real-time messages to the IV pump and the staff via their cellphone or tablet.

USE CASES: SIMPLE AND SOPHISTICATED

By allowing devices to talk to each other and to act automatically, efficiency can be increased, costs reduced, and healthcare improved. Here are a few examples:

EQUIPMENT TRACKING

As in any business, keeping track of assets is time-consuming. With devices connected to the IoT and monitored, equipment such as wheelchairs can be found by tapping a tablet rather than wandering the halls.

PREVENTIVE MAINTENANCE

For MRI machines to work properly, they need a continuous supply of liquid helium that reduces the resistance in the wires to almost zero. If the helium supply runs low and isn't ordered in time, these expensive-to-operate machines can become unusable, leading to interrupted patient and physician schedules and reduced revenue. If these machines and helium tanks were connected to the IoT and monitored and managed, a computer could order helium, schedule an installer to be available when no scans are scheduled and the helium tanks are available, and even schedule patients and clinicians for other available MRI machines.

INFECTION PREVENTION

There are plenty more things that can become part of the IoT for better, safer care. It's been reported that nearly 100,000 deaths occur every year due to healthcare-associated infections.² Many hospitals are installing connected faucets that monitor and account for proper hand washing by doctors, nurses, and other clinicians. By installing and utilizing smart-faucets, infections can be greatly reduced.

MEDICATION MONITORING

Electronic pill dispensers can now be connected and monitored over the Internet to ensure patients take the correct pills and dosage at the right times. Monitoring and alerting can prevent patients from missing their medication as well as prevent medicine abuse.

TRIAGE

Not only are IoT devices being installed in hospitals and homes, but also in between, in ambulances. Tablets, heart rate and blood pressure monitors, and even gurneys can be connected. Many gurneys are now equipped with sensors that calculate the patient's weight, monitor movement to determine if they are awake/coherent, and even track their temperature and heart rate. By the time the gurney and patient have been loaded into an ambulance, doctors back at the hospital can be making preparations for the patient's arrival.

REMOTE PATIENT MONITORING

Pill dispensers can be connected and monitored over the Internet to ensure patients take the right pills at the right times. Wearable devices can detect when a person has fallen and needs assistance or when someone suffering from COPD is emitting high volumes of carbon dioxide. Fast Data reduces data overload, allowing automation to handle lower level tasks and giving people more time to focus and think.

AUTOMATIC DISPATCH

From urgent-event data received from wearable devices (including patient location), medics can be dispatched immediately and automatically. In the event the nearest hospital doesn't have available staff, the best alternate facility can be alerted and the ambulance rerouted.

NANOTECHNOLOGY RECONNAISSANCE AND CONTROL

Nanotechnology researchers have been making amazing progress and it's just a matter of time before the technology becomes part of mainstream healthcare. Nano-devices will swim inside the human body, collect information, and even take action—perhaps seek and blast away cancer cells.

2 R. Monina Klevens et al. Estimating Health Care-Associated Infections and Deaths in U.S., US Center for Disease Control, http://www.cdc.gov/HAI/pdfs/hai/infections_deaths.pdf

SUMMARY

This paper explains how the TIBCO Fast Data platform is not only the optimum solution, but advanced enough to begin improving healthcare efficiency, cost, and quality now, by solving problems for the IoT.

These problems include alleviating data overload and addressing the hard challenges presented by device incompatibility and massive volumes of data. TIBCO Fast Data combines intelligent technologies with human insight to support a growing number of simple and sophisticated healthcare use cases.

Learn more about TIBCO and the Fast Data platform at www.tibco.com.



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