Smarter Messaging

R3 Messaging holds promise as a key technology for Smarter Planet solutions

By Jim Utsler

A smarter planet is necessarily instrumented with sensors to help monitor it. From energy grids to water supply systems, these sensors let organizations gather and manage massive flows of information. Take air-traffic surveillance for example. Multiple agencies need real-time data to make snap decisions to address quickly changing or unpredictable events, such as when an aircraft, for whatever reason, appears to be going off course. To that end, IBM Research and Boeing recently partnered for a First-of-a-Kind (FOAK) project to demonstrate the transportation of timely, consistent and complete information across the various organizations that oversee aviation.

A key component of this project was Responsive, Reliable and Real-Time (R3) Messaging. As its name implies, it provides a means by which information—including crucial sensor data—can be dependably routed from one source to another. As IBM Researcher Dr. Hui Lei explains, R3 Messaging goes well beyond conventional enterprise-messaging systems and promises to make an increasingly smarter planet even smarter still.

Q: What is R3 Messaging?
A: R3 Messaging can be considered a key enabler of IBM’s Smarter Planet vision, which includes three main
ingredients: instrumented, interconnected and intelligent. Instrumented is about how you deploy sensors everywhere around the world to gather information about different aspects of the real world. Interconnected involves moving sensor readings about the world to the back end in real time so you can conduct processing. That back-end processing analytics is the intelligent part. R3 Messaging, in a way, is an enabler for the interconnectivity aspect: how you can move data in a reliable, responsive and real-time manner.

Let me explain why we need those three Rs. As you know, sensor data is about things happening in the real world. There’s a real-time property there. If the sensor data is delivered too late, then its meaning will be lost. For example, if a piece of sensor data is about the current demand on the power grid and it’s delivered five minutes late, it may not be very useful to demand-response applications that require the latest information, because the state of the grid may have changed substantially since five minutes ago. That’s why responsiveness and real time are so important in messaging systems.

Why do we also need reliability? One reason is that the sensor data usually has to travel over unreliable communication networks. You might have sensors deployed in the fields and then you have the analytics happening in a back-end data center. The data center and the fields are often geographically dispersed and may span, for example, the entire nation or even across continents. In such a wide-area setting, many things can go wrong. Network links may go down, routers may fail and packets may get dropped. In addition, parts of the communication infrastructure may be based on a wireless medium, which is known to be even less reliable and more volatile than wired networks. Not only does the data need to be delivered reliably when any parts of the wide-area network fail, the delivery also must be completed in real time.

After you complete the analytic processing in the back end, you may then need to issue commands to control what’s happening in the field. You do that by sending a set of commands to the actuators in the field. Because what’s being controlled are often mission-critical systems, you also need to make sure that those commands don’t get lost. If they get lost, you’re going to mess up a lot of things and have potentially catastrophic consequences. That’s another reason why reliability is so important in such a messaging system.

We’ve developed several techniques to provide the three Rs requirements. For example, we have a technique called multipath routing, meaning multiple disjointed network paths are used to transport the same piece of data. In case

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one network path goes down, another path is still available to move messages, without causing much delay in message arrivals at the destination. Another technique is priority-based scheduling, or allocating resources like memory, CPU and network bandwidth to different messages based on the criticality of the messages. Higher priorities are given to messages that are more critical or urgent.

Q: What types of sensors are you talking about and how does R3 fit into this model?
A: R3 Messaging is a general-purpose messaging system that’s applicable to many Smarter Planet use cases. Consider the use case of national air surveillance. Many federal agencies—the FAA, the Department of Defense, the Department of Homeland Security and various law-enforcement agencies—are all involved in airspace monitoring and management. These agencies have their own sensors. Some sensors are on the ground, like radar. Some sensors are airborne and mounted on aircraft. These sensors collect information about what’s happening in the nation’s airspace. Different agencies need to share their respective sensor information with each other so they get the same picture about what’s happening out there.

Just imagine if the FAA had one view of the airspace based on their sensors and the Department of Defense had a different view based on their set of sensors. That wouldn’t work. They need to share the information and come up with a common understanding of the situation in the airspace. For this kind of cross-organizational, wide-area data exchange, you need to provide the three R properties. That’s one application scenario of R3 Messaging.

Another scenario has to do with the smart grid. You can use R3 in different ways in that area. Let me just describe one in particular. There are various kinds of demands placed on the power grid. Different buildings, homes and plants need different amounts of electricity at different times, and they place a demand on the power grid. If we can gather that demand information in real time, the power generation and distribution companies can then look at that information and determine the demand they have to support. Then they can do all of the planning they need, because they have a better understanding of what’s being required.

The power generation and distribution companies can also influence demand. So say the current demand is way beyond their capacity. They can send a message to the consumers of the electricity saying that if they reduce their electricity usage right now, they can get some incentives or a credit on their bills. Conversely, they can say they’re going to increase the price for electricity because the demand is so high. They need to pass that incentive or price information on to their consumers so the users can adapt.

Q: Going back to your airspace example, many organizations are involved in this with different systems and data types. How is this handled?

A: It’s true that different agencies have their own airspace-management systems. They do their own processing. They have their own data-collection mechanisms. On the other hand, they also need to share information among themselves. This is the capability we call federated messaging, which is messaging across independently administered domains. It’s not that one agency gives all the information it has to another agency unconditionally. Instead, each agency defines the subsets of information it’s willing to share or has to share with other agencies. Access control and authorization are important. It’s not that we just freely share everything. That wouldn’t be a secure way to handle things.

Another thing is that different agencies might have their own message formats and syntax, their own topics and so forth. To support sharing across the agencies, there need to be various kinds of message brokering for transformation and mapping.

“We employ several novel techniques within the R3 system to meet the dynamic quality-of-service needs of the applications.” —Dr. Hui Lei, IBM researcher

Additionally, when a large volume of data is transmitted over a wide area, it’s important to optimize the messaging performance as much as possible. For example, I might decide to compress messages before I send them out or block multiple messages together. Then on the receiving end, I can do the decompression or unblocking before I show that information to the end applications. There are various brokering and transformation techniques like these that can be very useful in federated messaging. That’s why R3 Messaging runs in concert with IBM’s WebSphere Message Broker (WMB).
transformation and brokering are delegated to WMB. We don’t need to do that within R3 Messaging because it’s already in the WMB product.

Q: Does R3 Messaging involve both hardware and software or is it primarily a software-based solution? 
A: R3 Messaging is a software-only solution. It comes as a middleware service. If you look at today’s network infrastructure, it’s composed of many different types of networks. Different organizations have their own networks that are also interconnected through a wide-area backhaul network. Those networks provide routine delivery. They’ll try to deliver messages with their best effort. However, they make no guarantees regarding the quality of their message-delivery service. A message might take 10 milliseconds to be delivered, or it might take 10 seconds or it might take forever because the message gets lost. That’s a common situation in many physical networks today.

R3 provides a messaging layer on top of today’s existing physical networks. We try to provide the R3 properties without having to make any changes to the underlying physical networks. So we’re providing an overlay on top of physical networks and then figuring out the best route to use to send particular messages. There might be different route options available.

In addition, different messages have different quality-of-service requirements because they’re on different topics or have different urgencies. When R3 delivers messages, it also takes that into account so that it will make the best use of precious network resources. We employ several novel techniques within the R3 system to meet the dynamic quality-of-service needs of the applications.

Q: Outside of the smart grid and air-traffic control issues, can R3 Messaging be used for other applications? 
A: Yes. Smart grids and air surveillance are just two of the application domains we have explored. We’ve also looked at how we can use R3 in water management, with sensors on rivers that allow us to monitor conditions in particular rivers. The net is that R3 Messaging goes beyond air traffic monitoring and the smart grid and has applicability to many Smarter Planet domains.

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