RTI CUSTOMER SNAPSHOT

European Space Agency

TELEROBOTICS & HAPTICS LABORATORY

"The SPAN telerobotics development platform allows us to assess the technology we've developed. We selected RTI for this advanced platform because their product seamlessly manages real-time closed-loop control over a highly challenged communication link. Just as importantly, it delivered a framework on which to build an extremely flexible development environment ideally suited to mechatronic development teams."

Dr. André Schiele
Head of Telerobotics & Haptics Laboratory, ESA

HIGHLIGHTS

- The ESA Telerobotics & Haptics Lab is a leader in telerobotic development involving semi-autonomous robots
- Technical challenges include high performance and reliability, the real-time communications link itself, and integration with different teams.
- ESA selected RTI Connext DDS as the connectivity framework for SPAN. In January 2015, a NASA astronaut executed the first successful force-feedback measurement experiment with SPAN on the ISS.

DEFINING THE FUTURE OF TELEROBOTIC DEVELOPMENT BUILT ON DDS

In the specialized field of robotics, telerobotics is at the forefront of innovation. Typical robotic systems are designed to move autonomously and to react to pre-defined stimuli in often repetitive, consistent ways. By contrast, telerobotics is concerned with semi-autonomous robots controlled by people, often from great distances away and responding to unpredictable environments.

A telerobotic device provides visual and sensory data back to the person operating it and responds to the human controller's movements, which are communicated through force-feedback or haptic (tactile feedback) technology. Telerobotic devices are designed to respond to the environment with the reactive capabilities of a human and, at the same time, to give the operator a visual and tactile sense of "being" the robot. Data is relayed between the telerobotic device and the operator through wireless communications.

The European Space Agency (ESA) is a leader in telerobotic development, which the agency sees as vital for space exploration. Telerobotics offer opportunities for discovery and research in places where it's impossible or unreasonable to send people. However, there are a number of significant challenges to building and deploying telerobotic systems for extraterrestrial missions – including system design, systems integration and long-distance communication. To help it solve some of its most difficult challenges, ESA turned to RTI.

CHALLENGES

One of the biggest technical challenges with telerobotics is the communication link itself. Managing a real-time control loop over the communication link is especially difficult for ESA because data must be sent between the International Space Station (ISS) and a planet's surface where the robot will be deployed. This requires a DIL (for Disconnected, Intermittent or Lossy) communication link. With a DIL link, which is characterized by extreme message latency and jitter, status needs to be continuously assessed and fed back into the control loop – in fact, link status is an active part of the control algorithm. It's critical that telerobotics systems operate effectively, even when consistent performance of

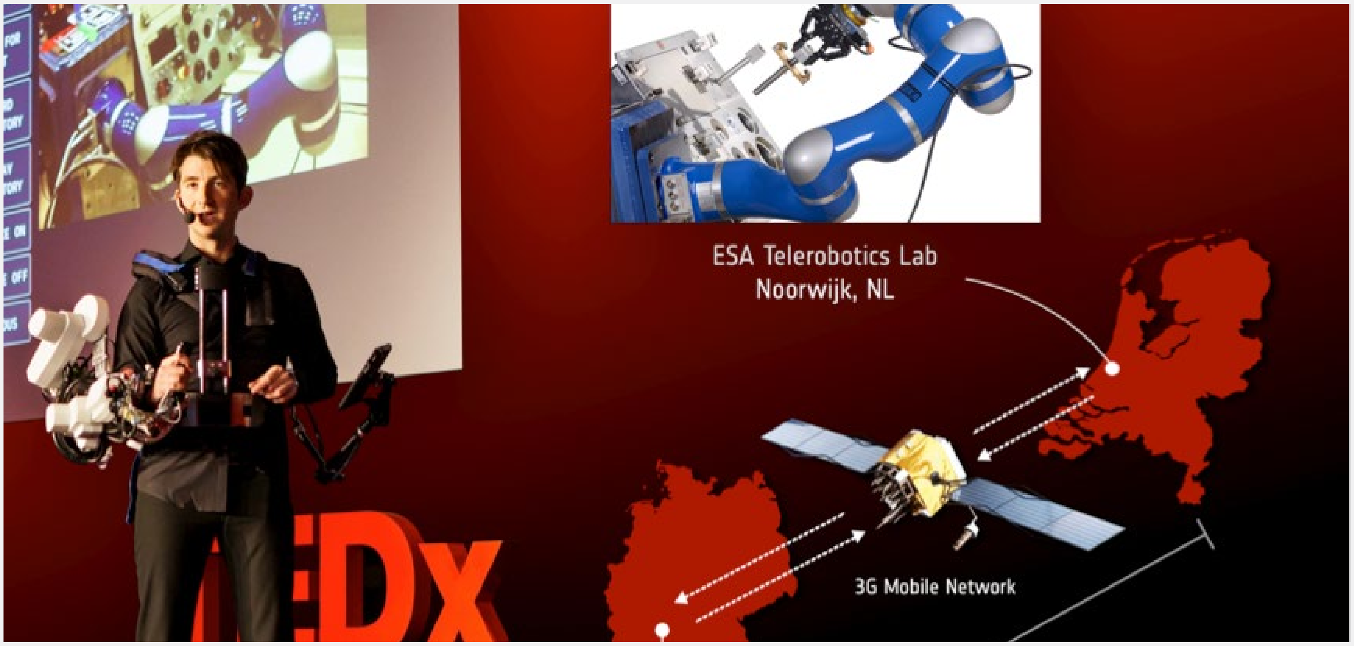

Figure 1. ESA demonstrating Telerobotics over a 2G phone link – with video feeds, augmented reality overlay, and real-time force-feedback. Click here to view the TEDx talk

the communication link is not assured. As much as possible, communications must be real-time and deterministic.

Creating systems for telerobotics is another significant challenge. Development teams are multi-disciplined and include mechatronic engineers, control theorists, vision system specialists, and human-computer interaction (HCI) specialists. Some have electronic or software backgrounds; others don't. Yet the system must integrate and support the specialist tools of each discipline. An integrated software toolchain is vital.

A third challenge is the newness of the technology combined with the need for guaranteed success. Rather than subcontracting design and development, ESA decided to build its own laboratory to focus exclusively on telerobotic devices. This lab would need to produce industry-quality systems that could execute their functions in space, where testing and development is not possible. This requirement set a very high bar for reliability and quality in all system elements.

SOLUTION

ESA recognized early on that the one consistent element of every specialists' sub-system development tool was that it produced or consumed data. They all use changes in data to represent state changes that other sub-systems may need to act upon. Even the imaging expert needed every frame of the video stream to be independently addressable and analyzable in order to provide feedback to the control algorithms or the HCI engineer.

Based on this realization, ESA decided to seek a data-centric system infrastructure for the foundation of the agency's development platform. The infrastructure had to deliver real-time communication capabilities and enable quality-of-service feedback into the control loop for moments when instability occurred. In addition, ESA's goal was to work with open, standards-based technology. As a state-funded entity, the agency knew its work would lay the foundation for wider market adoption.

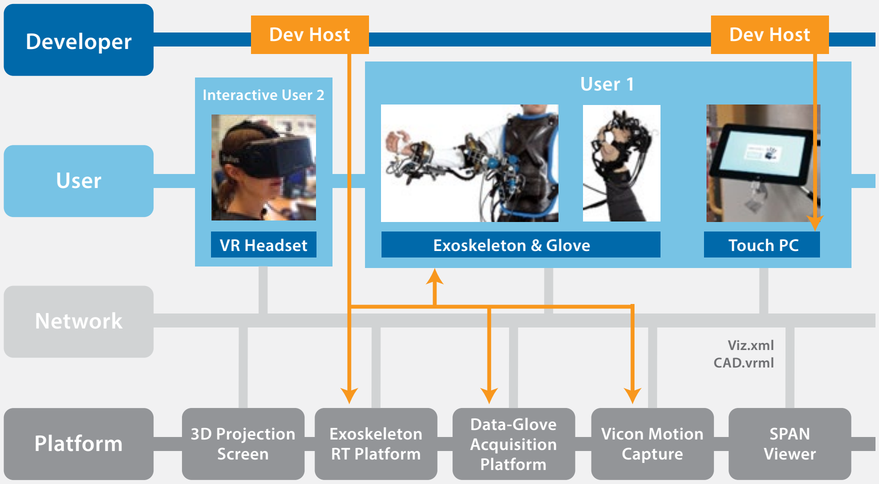

Figure 2. The Space Portable Applications Network (SPAN)

Figure 3. NASA astronaut Berry Wilmore executes first ever force-feedback experiment in space

This set of requirements led ESA to DDS. Data Distribution Service for Real-Time Systems, or DDS, is a set of specifications standardized by the Object Management Group (OMG). At its core, DDS implements a real-time software data bus based on a connectionless architecture. ESA also needed to create a robotic-specific platform from the real-time data-centric development platform, thus enabling the system to integrate a wide range of tools from the robotics and control systems market into one cohesive platform.

To build its new platform, "SPAN" for Space Portable Application Network, the ESA selected RTI Connext DDS.

SPAN has already been put to work in a series of experiments called Haptics-1, 2, and 3. The objective of Haptics-1 was to perform the first test of force-feedback in space. Haptics-1 was shuttled to the ISS in October 2014 where it would be used to provide calibration data for remote human manipulation of a telerobotics device.

BENEFITS

In January 2015, NASA astronaut Berry Wilmore executed the first ever force-feedback measurement experiment on the International Space Station. The system and experiment were successful. Equally important, the SPAN development platform validated its ability to deliver a real-time, space-based telerobotic system.

But the real value of SPAN, with its RTI Connext DDS foundation, is that it has enabled a multi-disciplined team to come together in a highly flexible development environment. SPAN enables autonomous and independent development of each specialist function with a 'right-by-design' data-centric underpinning. This means the integration exercise for each new system for test or deployment can become automated. In fact, SPAN already includes a large amount of auto-code generation based on the expressed needs of each independent developer.

ESA is confident that Haptics-2, which will test telerobotics force-feedback between space and earth, will also be successful, in part because NASA already uses RTI Connext DDS for much of its communication infrastructure. In addition, live tests (see Fig 1) at a TEDx conference were performed over a DIL 2G mobile phone link in a packed room full of mobile phone users. The link regularly exhibited characteristics like those encountered in space – such as jitter and high latency (up to several seconds). Yet the ESA demonstrator was able to place a steel pin in a hole with 0.5mm tolerance from a distance of over 500 kilometers, helped by augmented reality video running over the same link using RTI Connext DDS.

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℠.

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.

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