Delivering Results with RX MCUs and Unison RTOS

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Today's competitive world of embedded systems and the Internet of Things is placing ever greater demands on developers. Developers need to produce products that optimize size, weight and power (SWaP), and have focused feature sets that are also flexible so they can be quickly adapted to meet changing customer requirements. In terms of processors, this is greatly helped by having a family of microcontrollers not only built around a common, high-performance core that features low power consumption, but which, as a series, offers a range of selections in terms of on-chip functions and peripheral sets that present a compatible software platform.

Renesas RX microcontrollers (MCUs) are just such a family: The RX600/700 series with the fastest performance (up to 240MHz CPU speed), industry-leading 4MB of flash memory, and most advanced functions and I/O; the RX200 series, which delivers an optimal balance of power efficiency and high performance; and the entry-level RX100 series, with extremely low power consumption. The RX series encompasses a range of products that provide seamless scalability from small-scale to large-scale applications.

The associated embedded operating system requires standards that can also provide portability, flexibility and adaptability. Embedded Linux has become a very widely used and versatile operating system for embedded designs, but is generally limited to microprocessors that contain a memory management unit. Embedded POSIX is a standard that is fully compatible with Linux and is gaining ground because of its ability to run on microcontrollers. Since POSIX is defined by its API, it is possible for suppliers to implement innovative functionality such as real-time performance, security and the like behind that API and still remain POSIX-compliant.

The Unison RTOS by RoweBots is a real-time operating system (RTOS) that enables POSIX-compliant development on microprocessors, as well as microcontrollers that may have limited memory and core resources. Unison can provide a POSIX-compliant API from the most basic microcontroller up to a full-featured microprocessor.

Unison has been ported to each member of the Renesas RX family and scales in performance and functionality, from the entry level RX100 series up to the RX700 series. Unison plus RX MCUs provide developers with a solid platform on which to build a wide range of products by taking advantage of the ability to reuse source code, including open-source Linux application code, or even entire applications that can be modified and enhanced for greater functionality. Additionally, it encourages the reuse of knowledge related to existing and successful designs. Unison also contains a complete selection of drivers for on-chip peripherals, and protocols for networking and security that are pre-tested and can be quickly selected and integrated into the platform according to the application's requirements.

Table 1 illustrates how adaptable the combination of RX MCUs and Unison is. From simple devices through advanced systems, RX MCUs and Unison effortlessly adapt to meet the specific requirements of your project. With forethought put into delivering minimum risk, minimum time to market and minimum total cost of ownership by both Renesas and RoweBots, the combination of Unison and RX MCUs delivers results.

Application Description	***Embedded Linux Memory Requirements***	***RX MCU and Unison Memory Requirements***	
	RAM (approximate)	***Flash***	***RAM***
Semaphore demo, one thread and one timer	>10MB	9 KB	4.5 KB
TCP / TLS – one application thread, TCP/V4/V6 thread and TLS	>10MB	103 KB	63 KB
Bluetooth using Panasonic module, one thread, tty, HCI, GATT	>10MB	80 KB + 24 KB *(BT firmware)*	24 KB

Table 1*: Unison RTOS on RX MCUs represent a truly tiny implementation of embedded POSIX. Applications which are fully POSIX compliant can be run in limited resources on the family of RX MCUs without further optimization. Embedded Linux takes two to three orders of magnitude greater resources. Note that RX MCUs do not require an MMU, which increases performance and reduces resource requirements.*

Features that Rule in the Internet of Things

Such a series of ready-built, integrated platforms provides a powerful combination of features that support eight principles required for fast and efficient IoT development: lean, adaptable, secure, safe, connected, complete, Cloud-compatible and cutting edge. These features not only help guide development for focused design and meeting time-to-market demands, they also guarantee the functional considerations needed to work effectively in the Internet of Things.

With its rich modularity, Unison supports the *lean* development model by providing standardization, interchangeability of drivers, protocols and service modules, and portability of applications. This lets developers quickly adapt to changing customer requirements in the midst of a project. The integrated platform optimizes both hardware and software design on the go. This model can be adapted to almost any given set of corporate practices, product development approaches and software processes to reduce total time to market and total cost of ownership.

Those same features make it *adaptable*—able to meet new market demands for features and functionality. Developers are aiming at a moving target. Once a product is in place with a customer, the OEM must be able to quickly react to calls for additional features and expanded functionality—or even

a more narrowly focused, lower-cost version of a product. Existing code can be moved to a higher performance processor and new features quickly added without serious revision of existing code.

Security and *safety* go hand-in-hand and must be designed in from the ground up. If it can be hacked, it isn't safe. Security begins with the selection of a secure initial design and extends through communication protocols, incorporating such strategies as passwords, electronic key and physical recognition, the use of secure booting, encryption and many more. However, the judicious selection of the basic system architecture, hardware and software is also a key requirement. The Unison RTOS includes a rich set of security features that can be put in place at the foundation to build a secure system and application set.

The Unison RTOS was developed with *safety* in mind and offers two main features that help ensure safety in systems. Determinism guarantees quick response to threatening conditions and makes the operation of the system predictable so that it can be reliably tested to meet strict timing requirements. Emergency stop with zero boot time means that a device can be halted instantly and restarted with zero boot time if required. Thus, an unsafe condition can be halted immediately and brought back to a safe condition or the device diverted to an emergency action to deal with the crisis.

The Internet of Things has set new demands and criteria for *connected* embedded devices, and today's devices must accommodate a very broad range of sensors, both wired and wireless. Wired connections include Ethernet, USB 2.0 and 3.0, QSPI, SPI and MMC for storage, UART (with COM 1and 2) and GPIO with and without interrupts. In addition, a greater variety of wireless protocols is seamlessly supported. In addition to the various flavors of Wi-Fi (802.11a/b/g/n), there is also support for Bluetooth® Smart/Smart Ready, 802.15.4 with 6LoWPAN, along with 3G, 4G and UHF. Unison will deliver virtually any connectivity solution that can be selected and integrated into the RTOS design off the shelf. That means Unison is *complete* in that it contains everything you are likely to need for a project as it evolves, from connectivity to databases, file systems and HMI options.

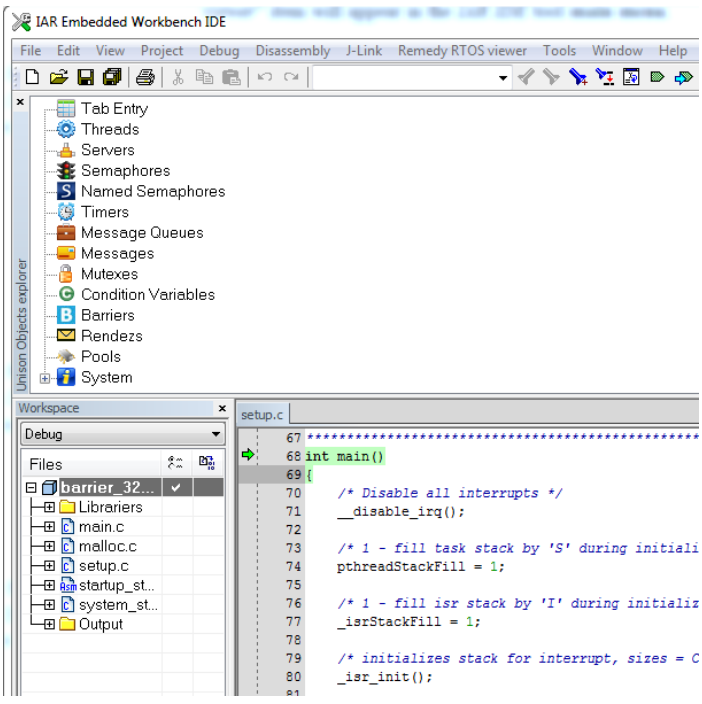

Figure 1*: The Remedy RTOS viewer is seamlessly integrated into the IDE of choice and provides detailed current information on all system objects.*

Unison supplies a broad set of protocols that can be used on the *Cloud* side to easily and securely connect and transfer data and process commands. The Internet of Things is growing and evolving rapidly and keeping up with its development requires the latest components and tools to deal with it and its newer applications. This means the ability to work with other leading-edge applications like Microsoft Azure. It also means the use of the best tools, such as a wide selection among the IDE offerings, along with advanced Unison support tools that allow use and tracking of Unison memory and objects (***Figure 1***) such as dials and gauges, plus timing tools and displays to understand scheduling, interrupt processing and more (***Figure 2***). The incorporation of these latest tools, protocols and technologies and their availability across the Renesas RX family makes this a truly *cutting-edge* platform.

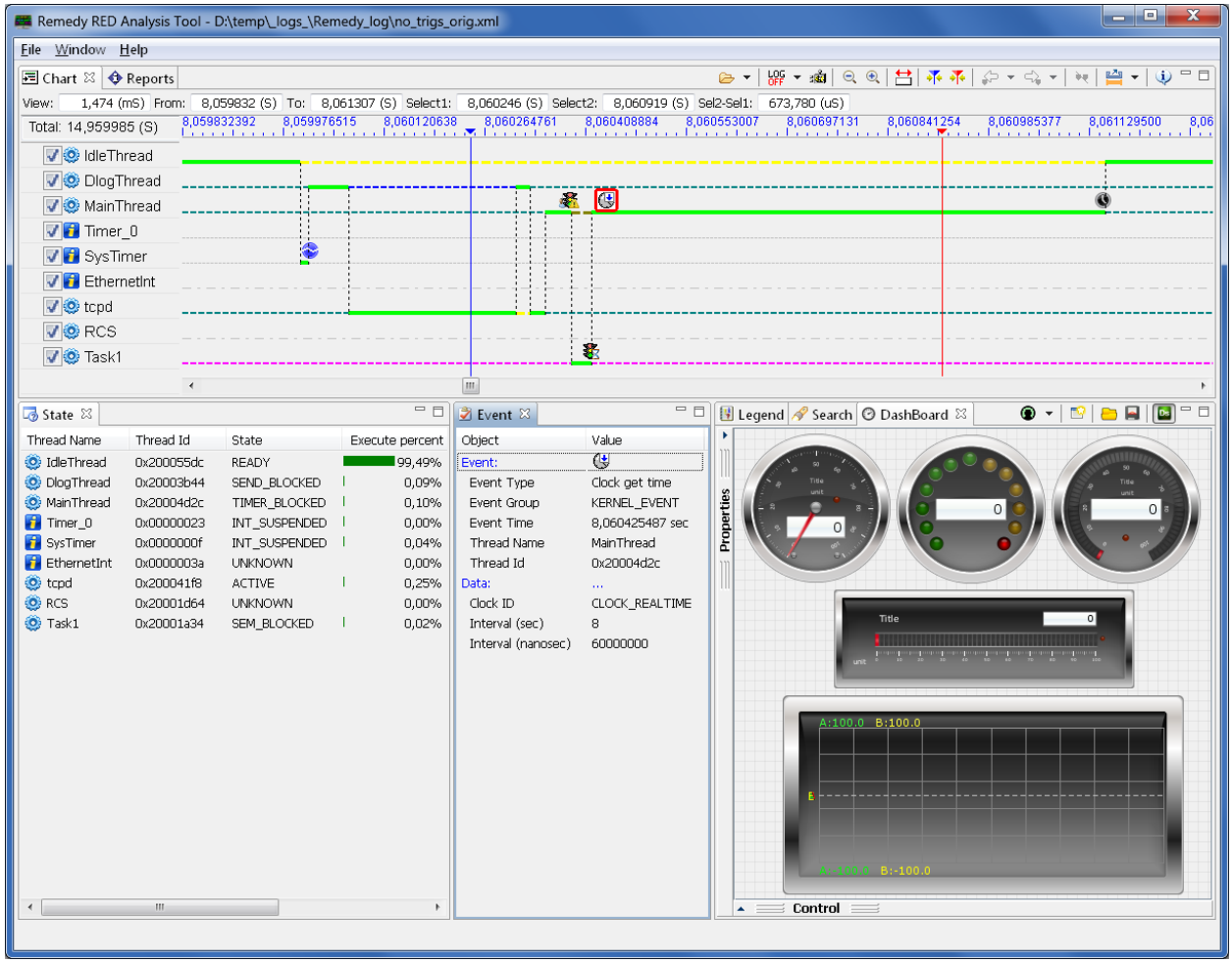

Figure 2*: Remedy RED is another example of the advanced tools provided with Unison as part of the core environment. It includes various rich display mechanisms, showing the actual execution sequences on the target device complete with utilization, thread states over time, and dials and gauges which are used to display data and transmit settings to the target.*

RX MCUs and Unison RTOS in Action

With the growing concern among communities and parents of the danger of concussion in sports like football, rugby, hockey, etc., RoweBots saw a need for a concussion detector that could provide early detection of hard hits and enable policy-governed responses to those events. A design approach using a pre-integrated hardware/software kit was used to conceive and quickly build the system using Microsoft Azure and a Renesas RX MCU with a pre-integrated Unison RTOS as a development platform.

In keeping with lean product development approaches, an agile approach with a multi-disciplinary team was used. The objective was to develop an operational system as quickly as possible based on a few core requirements and some broad objectives and then, using feedback from sports team coaches and medical support personnel, refine the system. Starting with a blank screen, in a mere 45 calendar days, using this off-the-shelf hardware and software, a complete Azure-based concussion monitoring system prototype was created with the RX63N MCU and Unison. With powerful Cloud tools and a completely integrated embedded RX MCU/Unison environment off the shelf, adding sensor processing and communications was all that was required to test the prototype. Refinements from this point resulted in a completed prototype system using Wi-Fi and Bluetooth shortly thereafter.

Note that the initial development was done with a RX63N MCU with 2M Flash and a 512K RAM footprint with a corresponding low cost. Using the scaling of the Renesas RX product family, and the adaptability of Unison RTOS, the RX231 was substituted for the final implementation of the sensor—which is worn by each player—fitting into less than 100KB of flash with a significant cost savings (***Table 1***).

The required wireless gateway to collect data from multiple players simultaneously was also implemented using the RX family. Support for Wi-Fi and wireline connections to the Cloud are both supported with complete security and optional SNMP network management options. Bluetooth is used to connect the sensors to the gateway (***Figure 3***).

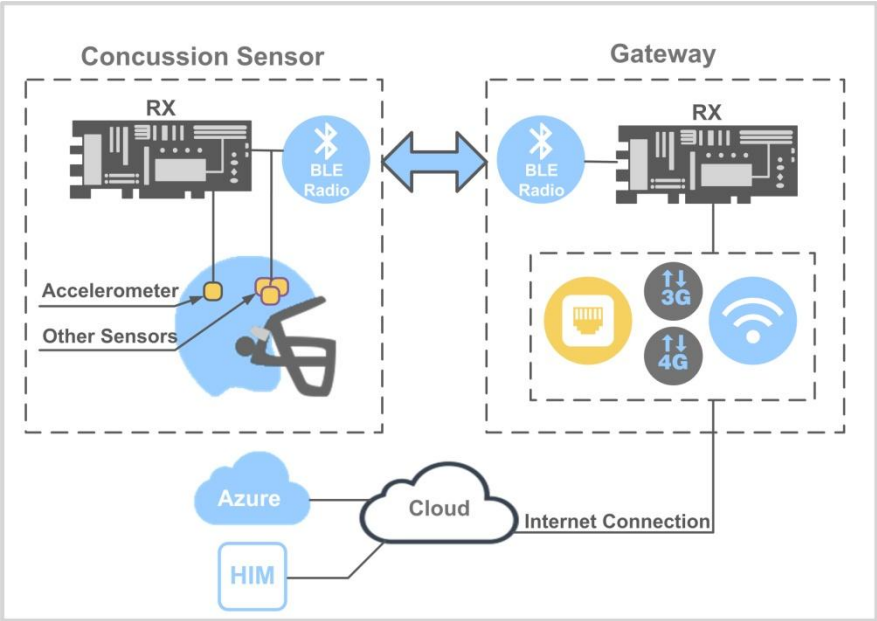

Figure 3*: The concussion monitoring system consists of sensors worn by the players, gateways that receive data from the sensors and the Azure-based Cloud application for analysis and alerts. All are built on Renesas processors of appropriate size and functionality running the Unison RTOS.*

A family of processors that can scale compatibly from the smallest embedded device through gateway and on to the Cloud, coupled with a rich, scalable RTOS aimed squarely at the Internet of Things gives the developer a solid foundation. Upon this POSIX compliant foundation, the developer can begin almost immediately to add value in terms of innovative applications. These applications can in turn be revised, expanded and scaled to other environments, including the Cloud, with no wasted effort, minimizing cost and speeding time to market.

Summary

The Unison RTOS, with full POSIX compliance, tiny memory footprint, and modular design, is ideally suited to run on the Renesas RX family of highly scalable MCUs. This combination helps developers to minimize risk, time to market, and total cost of ownership. To download Unison sample projects on Renesas RX MCUs, please visit the RoweBots web site:

http://rowebots.com/en/partners/hardware-partners/renesas/rxxxx-mcu-iar-ide