Software communication architecture: Evolution and status update

By Jeff Smith, Ph.D., David Murotake, Ph.D., and Antonio Martin

This article is a "must read" for anyone dealing with the SCA or its implementation. It gives a concise status overview, and it also identifies ties to other specifications and standards bodies such as OMG. - Ed.

Originally developed for the military's Joint Tactical Radio System (JTRS) program of Software Defined Radios (SDRs), the Software Communications Architecture (SCA) middleware is the key component to abstracting the underlying hardware from interoperable and programmable waveforms. The SCA, in effect, is what reprograms the radios to facilitate their reconfigurability. While the SCA remains strongly influenced by the JTRS program and the military, it's now also being considered for use in commercial and civilian applications. Throughout time, the SCA has evolved as users (civilian and military alike), industry committees, and complementary standards weigh in on SCA features and capabilities.

The SCA is a common specification standard and component-based software framework/architecture for SDR. The SCA is designed to facilitate waveform portability between different platforms and to leverage commercial standards, frameworks, and architectures to reduce development cost and improve reuse. Areas addressed by the SCA include waveform download, interoperability, operation and deployment on SDR devices, APIs (such as network layers, security, and common devices), and common component information.

While there are many interpretations of SDR, for the purposes of this article, external devices and the infrastructure composing the software bus will not be included as their future is independent of the SCA (for instance, they may be addressed by different standards bodies or deal with hardware migration). Instead, we will address the SCA by categorizing it into divisions of infrastructure, waveform support, services, device interfaces, heterogeneous processor, and security.

There are many permutations for a future SCA based on anticipated and existing commercial and government developments. To achieve future goals, it's key to address the challenges in future SCA development, commercialization, and adoption, and to summarize the current state of the SCA and future recommendations. Related commercialization and government standardization activities will certainly also affect the SCA efforts.

SCA evolution

SDR has a range of meanings today, depending on the types and number of hardware components that are replaced or upgraded by software. For simplicity, *SDR* is a term coined to describe a radio with a software-based physical layer that:

- Accepts fully programmable traffic and control information
- Supports a broad range of frequencies, air interfaces, and application software
- Supports over-the-air changes of initial configuration and waveforms

The SCA originated with the JTRS primarily to support SDR waveform portability for a new family of SDR tactical radios for the US military. The Software Defined Radio Forum (SDRF) assisted the JTRS Joint Program Office (JPO) in developing this open framework for SDRs, beginning with version 0.9 to the current version 3.0 (see jtrs.army.mil/sections/technicalinformation/fset_technical_sca.html) with its associated Application Program Interface (API), Specialized Hardware and Security Supplements. The Specialized Hardware Supplement is the main addition to SCA 3.0, which includes other improvements such as the elimination of reference counting and security supplement enhancements.

As the SDRF continues to support development of the SCA, it has sponsored the development of both an Open Source Reference Implementation (OSRI) for an SCA-compliant Core Framework (CF) as well as a compliant waveform based on FM3TR. The CF, based on a hybrid Java and C implementation, is available to SDRF members. An FM3TR waveform project is expected for completion later this year; in addition, the SDRF has developed requirements, use cases, Requests For Information (RFI), and Requests For Proposal (RFP). Typically, these technical products are voted and approved by the SDRF, then transferred via formal liaisons to other organizations such as the JTRS JPO and the Object Management Group (OMG), an object-oriented software standards organization.

For the last three years, SCA evolution has taken a parallel commercialization path in the Software Based Communications Domain Task Force (sbc.omg.org) within the OMG. In this forum, the domain-independent portions of the SCA, the bulk of the SCA, such as Lightweight Logging, Lightweight Services, Lightweight CORBA Component Model, Smart Antennae API, Digital Intermediate Frequency API, Deployment and Configuration of Components, and several Security Specifications, are in various phases of the standardization process as separate specifications. Development of these separate specifications allows commercial participation in related tooling and infrastructure.

Future SCA revisions should decrease in size and complexity as these OMG domain-independent specifications are completed and used as SCA references. This trend has already begun as the Lightweight Logging API was removed from the SCA, referencing the completed OMG version.

The OMG strives for SCA compatibility with its own software radio domain-specific version. Synchronization of OMG software radio specification improvements with the SCA has been achieved through liaisons and OMG member participation in the JTRS SCA Technical Advisory Group (TAG) revision process.

Existing SCA divisions

To simplify the categorization of changes, the SCA can be thought of in terms of current work and divisions as depicted in Figure 1. The current SCA 3.0 infrastructure manages the hardware radio components deployment by configuring devices and making sure they are ready, providing a standard store for configuration files, machine state, user attributes, and functional software, and offering a waveform structure, control, and binding framework for heterogeneous processors.

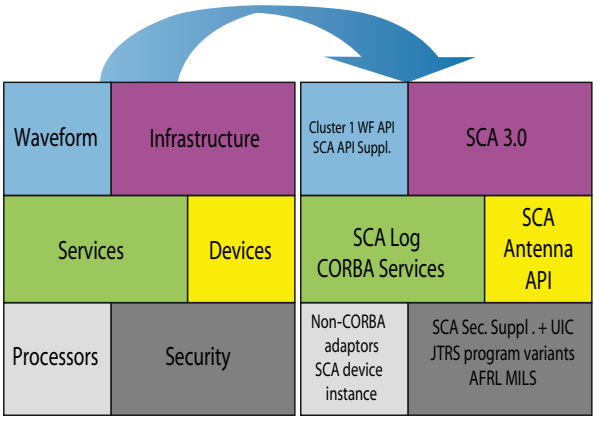

Figure 1

While not specifically addressing a waveform API, the SCA API supplement is given to support the portability of applications and interchangeability of devices; there is a specialization of the API derived from Cluster 1, a large SCA-compliant JTRS program. The current SCA assumes services that are provided by CORBA, for example, event and time services, and adds a logging service.

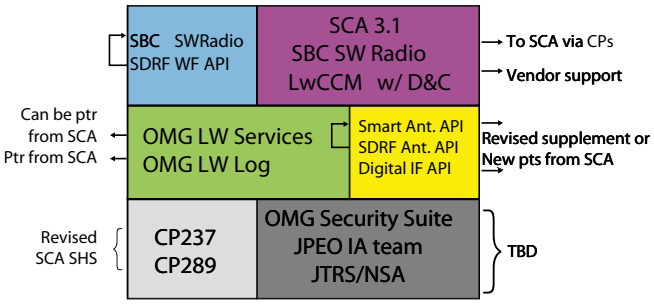

Figure 3

Device APIs, considered peripherals to the SDR, are also provided as an SCA supplement and at this time, an Antennae API is the only such supplement provided.

A standard method to access security functions such as encryption, authentication, transmission security (TRANSEC), and nonrepudiation, is specified in an SCA Security Supplement. Because of the nature of this technology, specializations exist for each JTRS program. In addition, there exists a parallel Air Force/NSA Multiple Independent Levels of Security (MILS) effort to combine the best of FAA DO-178B Common Criteria's security technologies, so as to provision secure services to embedded real-time, high-assurance platforms.

Parallel OMG standards plans and initiatives for the security functions and specifications are depicted in the OMG SCA Security Roadmap in Figure 2. A Specialized Hardware Specification SCA Supplement, available for SCA 3.0, specifies how to improve portability of software for processing elements other than general-purpose processors, including a Hardware Abstraction Layer (HAL) for deploying on heterogeneous processors.

Forecasted SCA divisions

Using the same divisions previously identified in Figures 1 and 2, Figure 3 shows a potential SCA evolution with possible choices. SCA changes occur through a Change Proposals (CPs) process and are reviewed though a Technical Advisory Group (TAG) and Change Control Board process. For instance, SCA 3.1 already

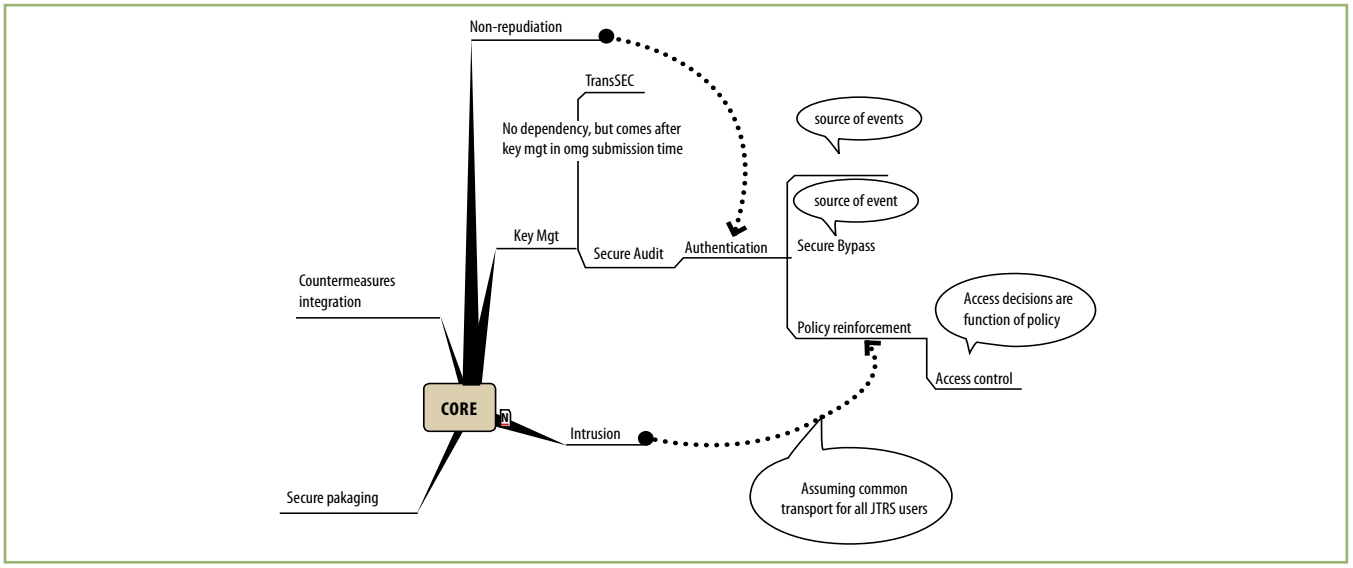

Figure 2

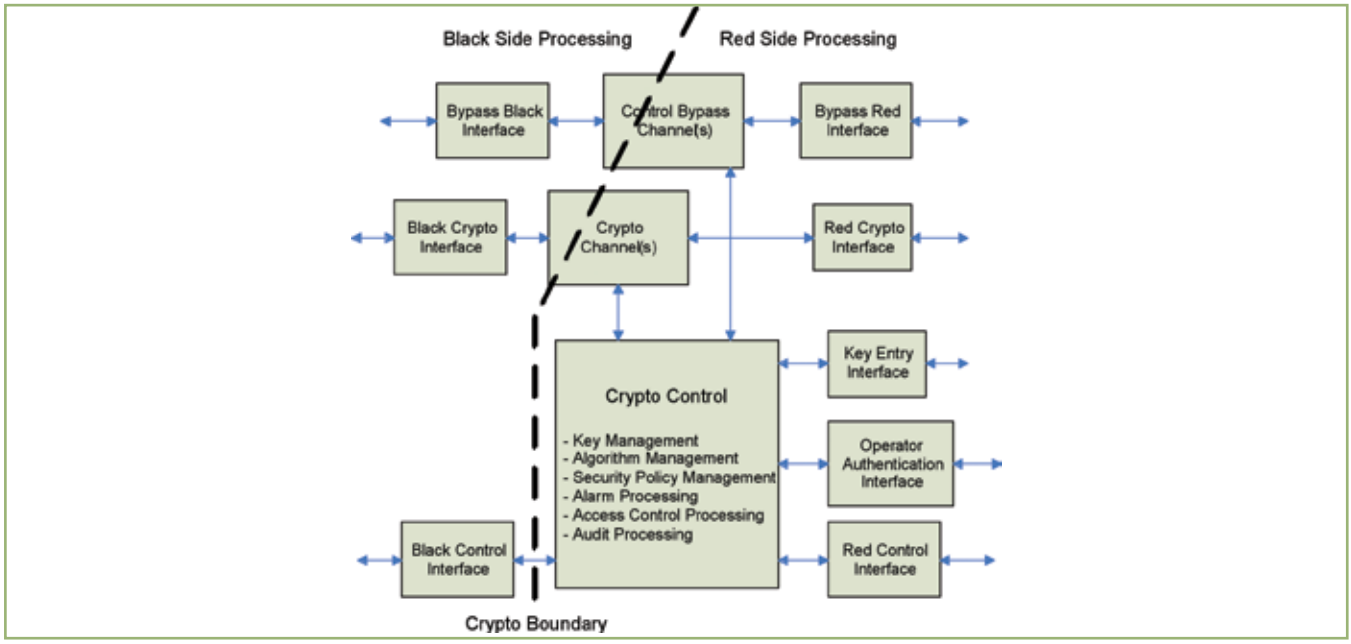

Figure 4

completed in draft form, includes CP289, detailing a Component Portability Specification (note CP289 was not accepted yet).

At this date, the OMG version of the Software Radio Specification is in the Finalization Task Force stage. This specification contains only the radio domain and waveform API portions of the specification, with the component model separated into different specifications that describe both the Deployment and Configuration of Components and Lightweight CORBA Component Model currently in the Revision Task Force stage. The SDRF is making additional progress with a new Waveform API contracted research and development project expected to begin in September, partially based on an OMG Software Radio Specification Waveform API Subset document. For the present, synchronization of the OMG and JTRS versions of the Software Radio specifications has been through OMG member participation in the JTRS CP process.

There are two new device-related specifications in process. The first is a Smart Antennae API Specification, with parallel efforts in both the SDRF and OMG. The second is an OMG Digital Intermediate Frequency (DIF) API Specification providing a standard API between tuners and the computer(s) hosting the rest of the software radio logic. This DIF specification is the software analog of the hardware standard driven through the digitalIF.org (www.digitalIF.org) standards group.

As previously mentioned, the OMG Lightweight Logging Specification has been finalized, serving as an SCA reference. The closest services specification to finalization is the OMG Lightweight Services Specification, offering a further reduction in SCA complexity.

The OMG Security Specification roadmap (refer back to Figure 2) is still in its initial phases; the first two specifications on this roadmap, the Core and Key Management Specifications, are in the initial submission stage. The OMG will standardize on the black, crypto, and red processing described in Figure 4. Common security requirements are combined into this Security Subsystem Core to describe the overlap in one specification. The Secure Audit and Authentication RFPs are complete, with initial submissions in work; the rest of the OMG security submissions in Figure 2 will follow. In the meantime: 1) There are JTRS/NSA planned upgrades to the SCA Security Supplement; and 2) the Joint Program Executive Office (JPEO) is putting together an Information Assurance team to plan upcoming security specification update and implementation testing.

Tuning in the future

If the trend to replace SCA sections with domain-independent portions continues, tool vendor support will increase. In addition, the SCA framework will be smaller, require less testing, and eventually support ultra lightweight deployments in small and low-power consumption devices. The OMG SWRadio domain-specific specification will, in the short term, contribute to the SCA though the JTRS SCA change process. The progression from SCA 3.0 to SCA 3.1 will support true waveform component portability over heterogeneous processors.

Commercial SCA adoption is still hampered by many factors such as tool and predefined component availability. Future integration of SCA and commercial Software Defined basestation specifications holds promise as competing commercial standards and the SCA improve with liaisons and information sharing between groups.

Jeff Smith *received his Ph.D. from Northeastern University in computer systems engineering, his MS in engineering management from Southern Methodist University, his MS in computer science from East Texas State University, and his BS in computer systems engineering from the University of Massachusetts. He has a 30-year track record in the acquisition, management, research, and development of advanced development/technology programs and heads a consulting company, Composable Logic, supporting SCA Technica.*

He is one of three co-chairs of the OMG Software-Based Communications Task Force and participates with the OMG Ontology working group. His primary expertise is in modeling/ formal methods and applied complex systems (multi-sensor fusion or software radio applications).

For more information, contact Jeff at:
Composable Logic
PO Box 3148
Nashua, NH 03061-3148
Tel: 603-566-0124
Fax: 603-222-2098
E-mail: jesmith@ComposableLogic.com
Website: www.ComposableLogic.com

David Murotake *received his SB in electrical engineering, SB in English literature and creative writing, SM in electrical engineering and computer science, and a Ph.D. in management of technological innovation from MIT. With more than 30 years of engineering and management experience at the US Army, RCA, GE, Lockheed, and Mercury Computer, he founded SCA Technica, Inc. in 2002. SCA Technica specializes in research and development of high-assurance SDR and CR and developed the High Assurance Wireless Computing System (HAWCS™) for protecting SDR and wireless computers from blended radio and Internet "hacking" attacks. A member of the SDRF board of directors, Murotake chairs its markets committee and is its Technical Committee's past vice-chair. He is founder and chair of numerous SDR working groups and special interest groups, including the Base Station WG and R & D WG.*

For more information, contact David at:
SCA Technica, Inc.
PO Box 3148
Nashua, NH 03061-3148
Tel: 603-321-6536
Fax: 603-222-2098
E-mail: dmurotak@scatechnica.com
Website: www.scatechnica.com

Antonio Martin *holds a bachelor's degree from the University of Maine in computer science and is pursuing a master's, certified by the Committee on National Security Systems, in computer science with a concentration in security at Boston University. Tony has eight years experience in the fields of biometrics, image processing, scalable distributed database and transaction processing, and network and system security. He is a participant at the OMG SW Radio FTF.*

For more information, contact Antonio at:
SCA Technica, Inc.
PO Box 3148
Nashua, NH 03061-3148
Tel: 603-321-5220
Fax: 603-222-2098
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Bus	AT Expansion Bus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	PCI Universal Expansion Bus		✓		✓		✓		✓		✓		✓		
	PC/104-*Plus* PCI Bus Masters		4		4		4		4		4		4		
	APIC (add'l PCI interrupts)	9	9	9	9										
CPU and BIOS	CPU Max Clock Rate (MHz)	650	650	650	650	1G	1G	1G	1G	333	333	333	333	100	100
	ACPI 2.0 Power Mgmt	✓	✓	✓	✓	✓	✓	✓	✓						
	Max Onboard DRAM (MB)	512	512	512	512	512	512	512	512	256	256	256	256	32	32
	RTD Enhanced Flash BIOS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Nonvolatile Configuration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Quick Boot Option Installed	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fail Safe Boot ROM (KB)	768	768	768	768	768	768	768	768	768	768	768	768	384	384
	USB Boot	✓	✓	✓	✓	✓	✓	✓	✓						
Peripherals	Watchdog Timer & RTC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	IDE and Floppy Controllers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	SSD Sockets, 32 DIP	1	1	1	1	1	1	1	1	1	1	1	1	2	1
	Audio	✓	✓	✓	✓	✓	✓	✓	✓						
	TFT Panel TTL or LVDS			✓	✓			✓	✓	✓	✓	✓	✓		
	SVGA Interface	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	AT Keyboard/Utility Port	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	PS/2 Mouse	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	USB Mouse/Keyboard	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
I/O	RS-232/422/485 Ports	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	USB Ports	2	2	2	2	2	2	2	2	2	2	2	2		
	10/100Base-T Ethernet	1	1	1	1	1	1	1	1			1	1		
	ECP Parallel Port	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	aDIO™ (Advanced Digital I/O)	18	18	18	18	18	18	18	18	18	18	18	18		
	multiPort™(aDIO, ECP, FDC)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
SW	ROM-DOS Installed	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	DOS, Windows, Linux	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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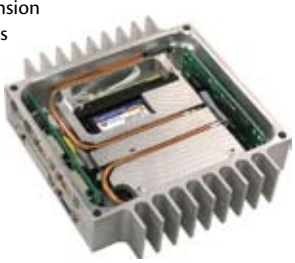

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