COMPONENT-BASED DEVELOPMENT OF RADIO SYSTEMS AND SUBSYSTEMS: ARE WE THERE YET?

The June 2005 "Trends in DSP" column explored the concept of component-based development for radio systems and subsystems [1]. In this model the intermediate frequency (IF) and baseband signal processing associated with each wireless air interface standard on a given radio product are created from encapsulated software, hardware, and firmware intellectual property (IP) that can be reused from product to product. The benefits of this model are obvious: component-based processing can shave months, or even years, off of the development time for the radio system or subsystem, speeding time to market and significantly reducing development costs. Since the publication of that column, there has been an ongoing increase in wireless standards, with radio devices now commonly supporting three, four, five, or even more wireless standards within the same product. With this proliferation of standards, it would seem that the need for component-based development is now stronger than ever, allowing radio terminal and infrastructure system manufacturers to more easily mix and match air interface technologies as necessary to support the needs of specific market segments. The technology providers supporting these manufacturers have responded accordingly, resulting in a host of new component-based development offerings available to communications systems engineers. Given this level of activity over the last two years in the area of component-based development, it seems reasonable to explore the question "are we there yet?"

This question can be answered by evaluating the status of the four key technology areas that were postulated in the June 2005 column as requiring "mature standards that are broadly accepted across the wireless industry" in order to achieve the vision for component-based development. These technology areas are as follows.

A COMMON MODELING "LANGUAGE"

This language allows the disparate development teams involved in wireless systems development to communicate in a common manner on the design of the wireless system. In the June 2005 column, two standards were highlighted as incumbents suitable in defining a basis for such a language: the Specifications and Description Language (SDL) maintained as a standard by the International Telecommunications Union (ITU) and the Unified Modeling Language (UML) maintained by the Object Management Group (OMG). Since 2005 there have been two key advancements in the area of common modeling languages:

- In May 2006, the OMG published the adopted specification for the System Modeling Language (SysML) [2]. This language extends UML with constructs inherent in SDL to provide "a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems that may include hardware, software, information, personnel, procedures, and facilities." This specification is scheduled for finalization this year and could provide a sound basis for defining a common modeling "language" supporting component-based development of wireless systems.
- In June 2006, the Spirit Consortium sent the IP-XACT specifications to the IEEE for standardization under the P1685 working group [3]. IP-XACT is designed to "provide a unified set of specifications based on IP meta-data for importing complex IP bundles into System-on-Chip design tool sets, and exchanging design descriptions between tools" [4]. A key part of these specifications is the IP-XACT IP meta-data description, which provides a common and language-neutral way to describe IP.

SysML and IP-XACT appear to define key elements necessary in creating a common modeling language that can be utilized in component-based development of wireless systems. For the vision of component based development to be fully realized, SysML will need to be extended beyond its general-purpose roots to provide a profile specific to wireless systems design, incorporating component models based on the IP-XACT specification as appropriate.

STANDARD "WAVEFORM FUNCTIONAL BLOCKS"

These blocks are supplied by device vendors to provide functionality, such as a quaternary phase shift keying (QPSK) demodulator, that is common in a wireless system. Support for an idealized component-based development model requires the functional description of each component to be standardized, including the definitions of the components input, output, and control ports, in a manner that is independent of component provider or device technology. This allows the wireless system designer to choose whether, for example, to deploy the QPSK demodulator on a digital signal processor (DSP) using one vendor's implementation or on a field programmable gate array (FPGA) using another vendor's implementation, based on the resource utilization and performance implications associated with the selection.

A number of device vendors, either directly or through third-party technology partner programs, offer extensive collections of waveform functional blocks targeted at wireless systems. These blocks are provided in the form of off-the-shelf IP cores, such as those offered through Xilinx's IP Center, or as signal processing modules, such as those offered by Texas Instruments through their eXpressDSP Third Party Program [5, 6]. These types of components are generally offered as a mechanism to speed development time and thus reduce the time from product concept to volume production. To date, however, there are no vendor neutral standards for defining these blocks. From a business perspective, this is not surprising, as there is little economic incentive for a device manufacturer to support a standard that simplifies moving a function to a competing device technology. Some effort was made by the U.S. Joint Tactical Radio System (JTRS) program to standardize waveform functional blocks in the Specialized Hardware supplement of Software Communications Architecture (SCA) Version 3.0, but these blocks were insufficiently defined to be useful, and SCA 3.0 as a whole was eventually deemed unsupported by the JTRS program [7]. Ultimately, if a sufficient number of device vendors provide IP for a sufficient number of functional components, the need for standardized waveform functional blocks may become moot, as de facto standards for each block will naturally emerge.

COMMON HARDWARE ABSTRACTION

This layer abstracts the connections between component blocks operating on different devices, allowing those components to interoperate regardless of radio architecture. As reported in the June 2005 column, there are a number of device centric component models for supporting this level of abstraction, such as the Open Cores Protocol and the TI eXpressDSP Algorithm Standard (XDAIS). Some work has been done since then in organizations such as the Service Availability Forum and Open Clovis to define standards for hardware abstraction at this level in wireless infrastructure systems, but those standards today offer limited support for the specialized processing devices such as DSPs inherent in many radio products [8, 9]. One group that does seem to be defining standards for common hardware abstraction on a broad basis is the Multicore Association [10]. This group is developing a Communications Application Programming Interface and a Transparent Interprocess Communications Protocol designed specifically to support multiprocessor and multiprocessor-on-a-chip system designs. While still in early stages, the work by this association could define a strong basis for a common hardware abstraction layer moving forward.

STANDARD APPLICATIONS FRAMEWORKS

These frameworks provide a standard mechanism for loading, unloading, monitoring, and controlling functional components on the radio platform. At the time of writing the June 2005 column, the most mature application framework supporting these capabilities appeared to be the Software Communication Architecture Core Framework developed in support of the JTRS Program. Since then, while little work has been done to define a similar type of framework for use in mobile or terminal radio solutions, the Scope Alliance has "standardized" on an application framework for wireless infrastructure systems [11]. The Scope Alliance is a consortium of commercial telecommunications equipment providers that was founded in January 2006 by Alcatel, Ericsson, Motorola, NEC, Nokia, and Siemens with a goal of "developing profiles for, as well as identifying gaps in, existing open specifications and prioritizing the importance of implementations of these specifications in the Carrier Grade Base Platform (CGBP) ecosystem." Under that mandate, the Scope Alliance has defined a profile for a standard application framework, similar to the SCA, based on the Service Availability Forum's Application Interface and Hardware Platform Interface specifications. This profile has the potential to act as the predominant application framework for wireless infrastructure systems for the next several years.

So, with all of this in mind, are we there yet? The short answer is: we're pretty close. Significant progress has been made in many of the technology areas cited as required in the June 2005 "Trends in DSP" column. While there is still work to be done, especially in the area of common hardware abstraction for multiprocessor wireless systems, it is reasonable to assume that the vision of component-based radio system development is finally within our reach.

REFERENCES

[1] L. Pucker, "Trends in DSP — Is the Wireless Industry Ready for Component-Based System Development?" *IEEE Commun. Mag.*, vol. 43, no. 6, June 2005, pp. 6–8

[2] OMG, "OMG Systems Modeling Language," http://www.omgsysml.org/

[3] The Spirit Consortium, "The SPIRIT Consortium Sends IP-XACT Specification to IEEE," http://www.spiritconsortium.org/press/061206

[4] The Spirit Consortium, "About the Spirit Consortium," http://www.spiritconsortium.org/about/

[5] Xilinx, "Intellectual Property," http://www.xilinx.com/ipcenter/

[6] TI, "About eXpressDSP Software," http://focus.ti.com/dsp/docs/dspsupportnp.tsp?sectionId=3&tabId=431&familyId=44

[7] JPEO JTRS, "Software Communications Architecture Change Proposal #198," http://jtrs.spawar.navy.mil/sca/changeproposals_detail.asp?ID=198

[8] A. Naseem, "SA Forum Interface Specifications — An Introduction," http://www.telecommagazine.com/newsglobe/article.asp?HH_ID=AR_2899

[9] Open Clovis, "A Modular, Cost-Effective Application Service Platform Software for Next-Generation Communication Systems," http://www.openclovis.com/downloads/ProductBro_01.pdf

[10] Multicore Assn., "About the Multicore Association," http://www.multicore-association.org/about.html

[11] Scope Alliance, "Scoping the SCOPE — Closing the Gaps of Open Carrier Grade Base Platforms Version 1.1," http://www.scope-alliance.org/scope-technical-position.pdf