Lessons Learned from Tactical Radio Interface Standardization

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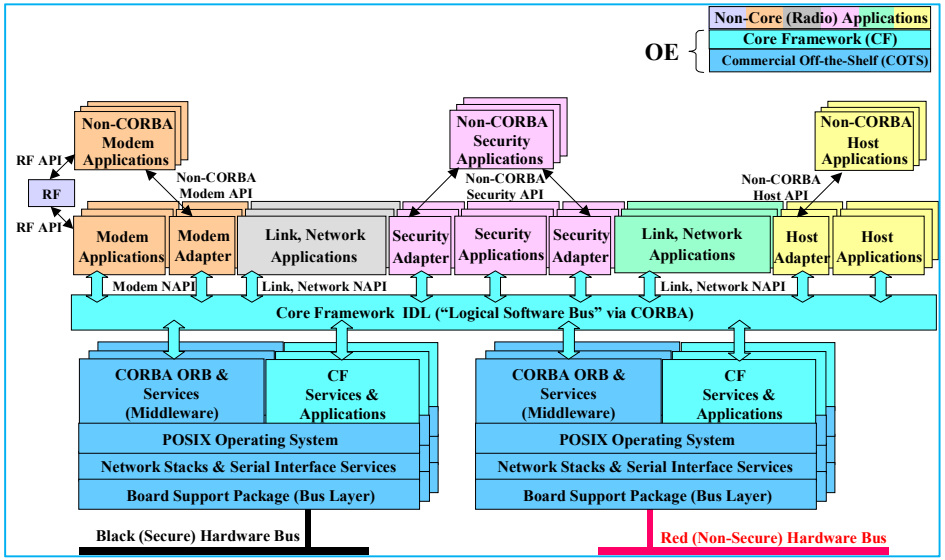
Software Communications Architecture (SCA) Framework

The Software Communications Architecture (SCA) was an early product of the Joint Tactical Radio System (JTRS) program, with SCA 0.1 released December 1, 1999.

It was a software-centric vision, with the idea that hundreds of reusable components could be dynamically linked together to form applications and waveforms.

Original SCA Architecture



- The SCA became non-domain specific – no radio-specific interfaces were defined
- The SCA documentation encouraged programs and industry to develop standardized application programming interfaces (APIs).

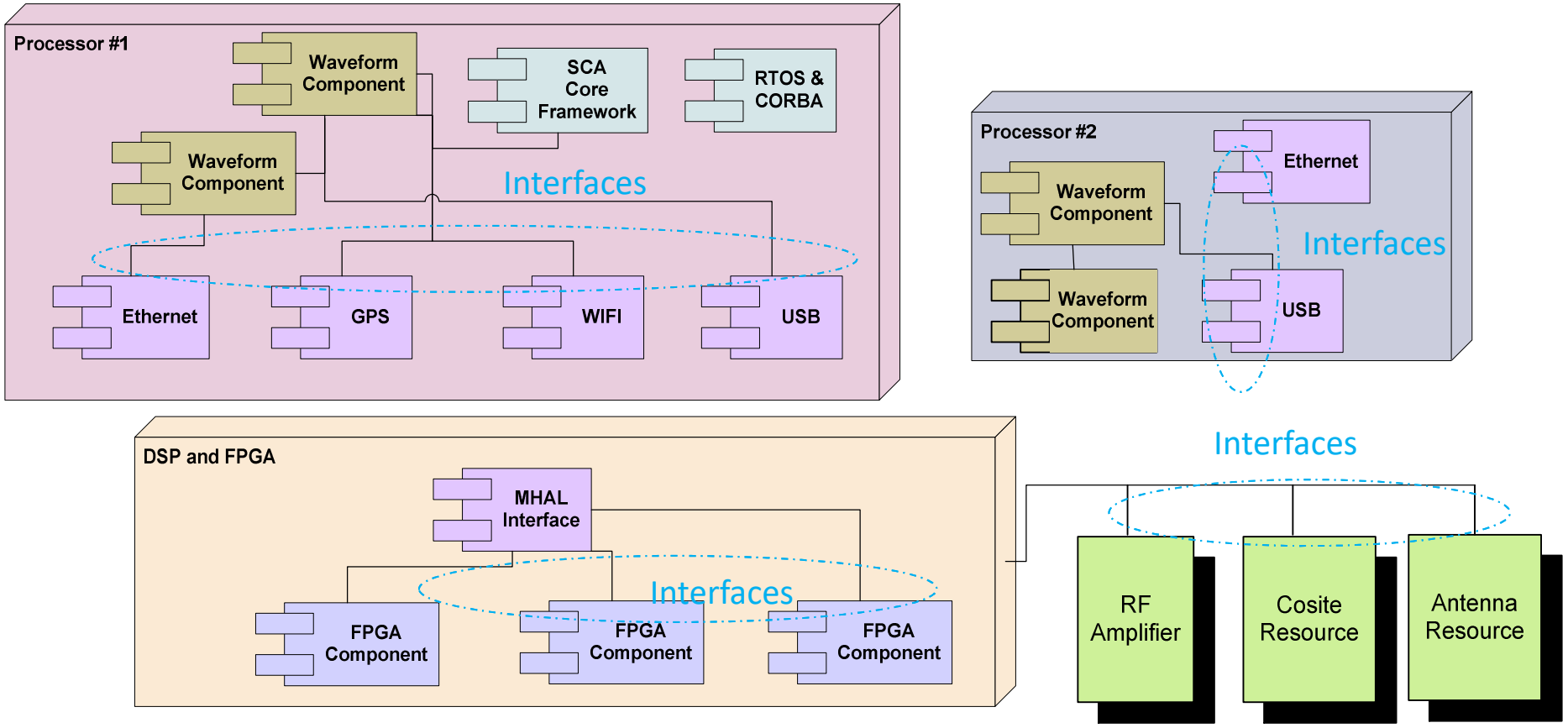
The Need for Tactical Radio Standards

The first waveform was ported to multiple Joint Tactical Radio (JTR) sets and porting effort was 6x expectations.

Porting Deficiency	Corrective Action
Absence of JTR Set APIs	JTRS Standards was established for APIs and standards
Missing Files and Documents	JTRS Software Standard specified required documents and directory structure
Missing Functionality	JTRS Software Standard specified required software package content
Absence of DSP and FPGA Specifications	APIs developed for DSPs and FPGAs
Waveform Connection Complexity	Developer education and SCA changes
Security Compliance	Developer education and participation by NSA

- The government had waited expectantly six years for industry, Object Management Group (OMG), Software Defined Radio (SDR) Forum, etc., to bring a set of APIs and standards for SDRs, but it didn't happen
- Consequently the government had to step in and create the standards

Identifying the Tactical Radio Interfaces



- In 2005, radio-specific interfaces had not been defined
- The original SCA concept was industry would define them

Generating Open Systems Interfaces

The Standards team requested guidance and participation from the DoD's Modular Open Systems Architecture (MOSA) project, then named Open Systems Joint Task Force (OSTJF).

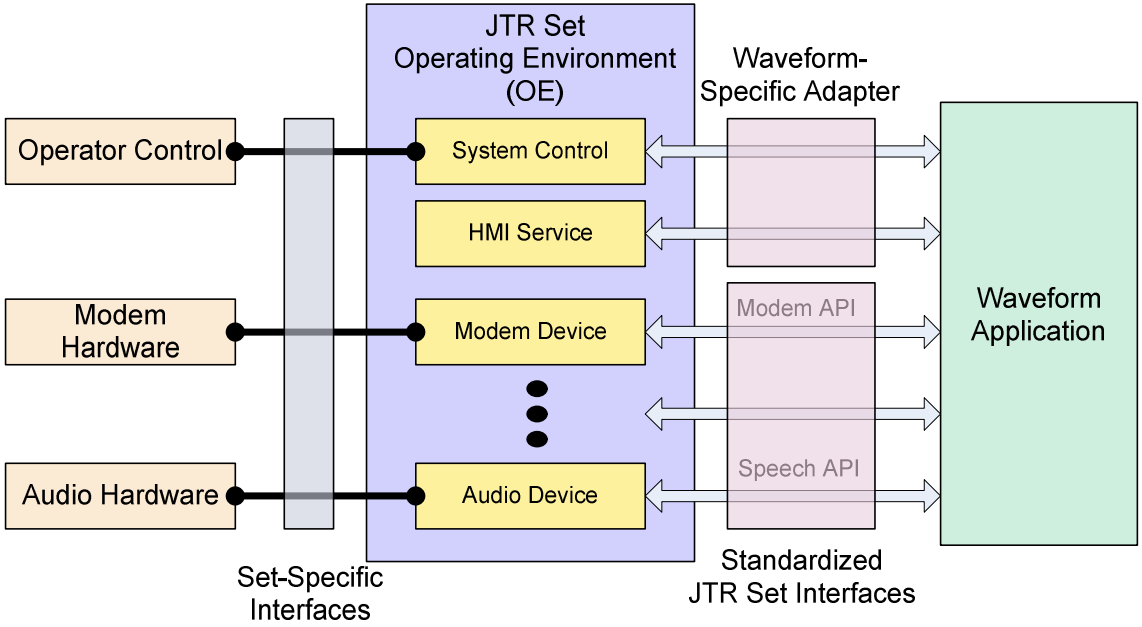
An Open System is an assembly of interacting components which perform according to their interface specification
- Key interfaces fully defined
- Available to the public
- Maintained through group consensus

Business model considerations:
1) Data rights and licensing
2) Life cycle sustainment strategy (plug and play)
3) Modular designs with loose coupling
4) Lower development risk through system-level designs

Design Patterns for the APIs

Only interfaces between the waveform and the radio set were standardized.

Internal waveform and radio APIs were allowed to be vendor or implementation unique.



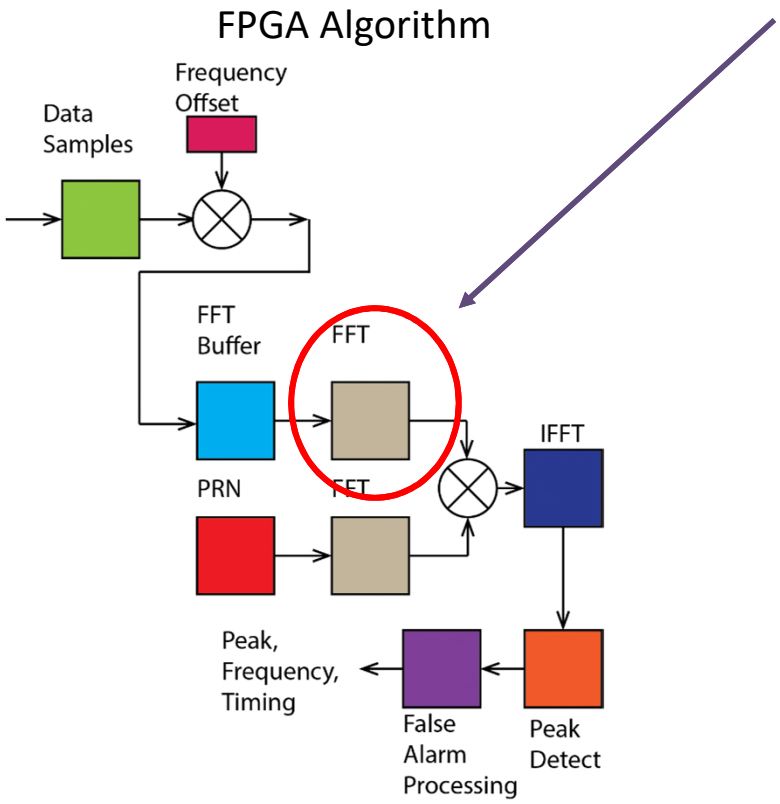
We discovered that simply defining open systems APIs was insufficient.

We had to include design patterns in the APIs to enable:

a) aggregation,
b) least privilege
c) extension
d) explicit enumeration
e) deprecation

Example: Fine Grain Interface – FPGA Portability

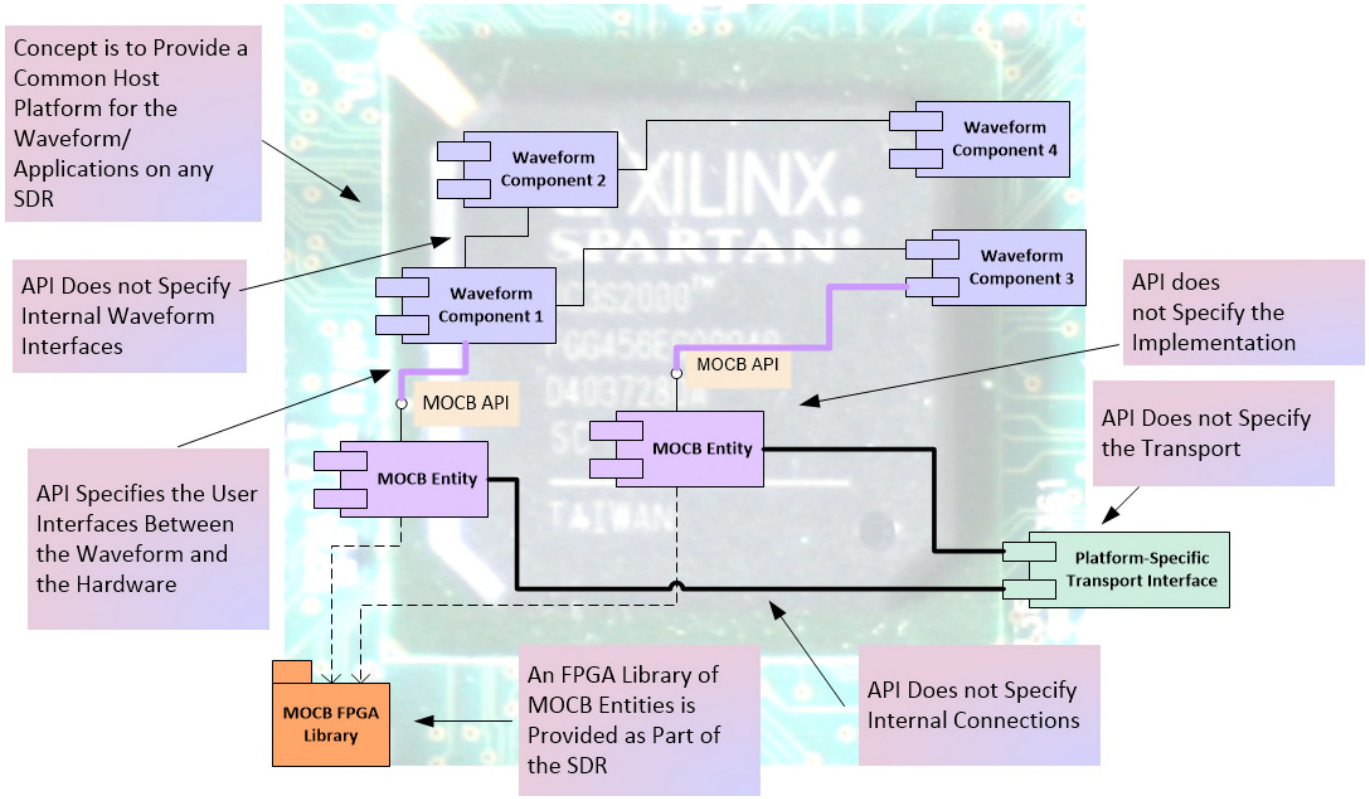
The use case itself is very simple – how to achieve portability of Field Programmable Gate Array (FPGA) code.



- When developing the Verilog or other code for the FPGA, designers want to use manufacturer-optimized intellectual property instead of hand-writing a function such as a Fast Fourier Transform (FFT)
- The interfaces for these intellectual property blocks are not the same across manufacturers
- Consequently the FPGA source code must be modified when porting from one manufacturer to another

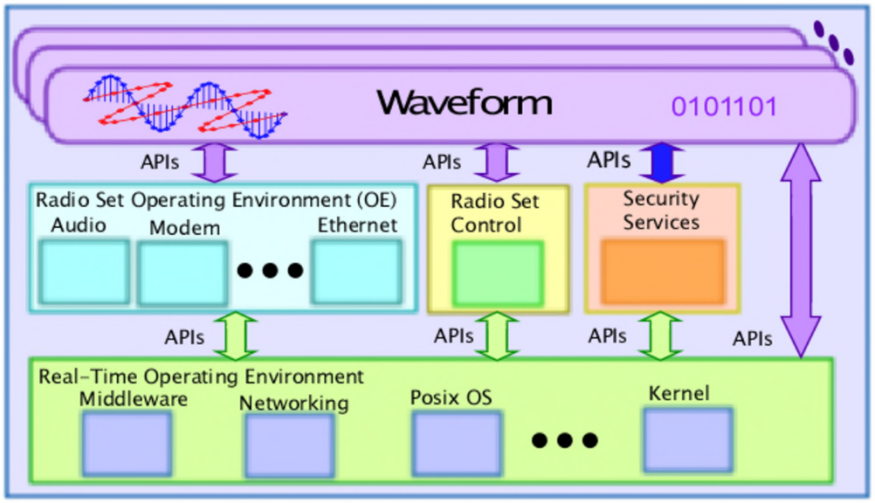
```
// enable the fifo read by for fft input // state 13
s_data_fifo_enable_rd: begin start_fft <= 0;
fifo_rden <= 1;
// enable fifo read //(one cycle delay before data valid)
// prn_fft_state <= s_data_fft_wrt; prn_fft_state <=
s_data_fft_wait_complete;
end // wait for the FFT to complete // state 14
 s_data_fft_wait_complete: begin
 if (fft_complete) begin prn_fft_state <= s_data_fft_wait_unload_done;
end if
(fft_edone) fifo_rden <= 1'b0;
// disable read ops
end
```

Elevating the Interface: Modem Hardware Abstraction Layer (MHAL) On Chip Bus (MOCB)



- The API specifies an interface to an MOCB block on the FPGA
- Within the MOCB block, designers can specify their unique interfaces
- The interfaces between the MOCB block and other MOCB blocks are defined

Example: Radio Security Services – Enabling Portability



An essential capability of a tactical radio is security services.

Security services are frequently developed independently of the radio set and waveforms, requiring integration between three different groups.

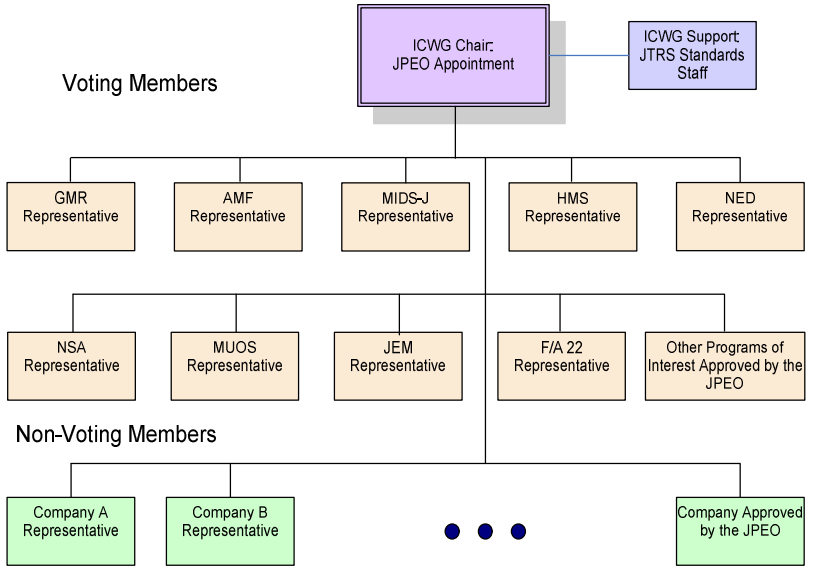
- Radio Security Services is an API that isolates the waveform, radio set, and the security services
- This API required subject matter experts (SME) and government agency coordination
- The API decouples waveform porting from the radio-specific security implementations
- Radio Security Services is the most complex tactical radio API

Standards Body

Essential to open systems standards is a standards body.

- Product demand – compelling need for standards
- Membership composed of multiple organizations or programs
- Technical and business interests represented
- Funding for communications and configuration management
- Access to subject matter experts (SMEs) as required

Original Standards Body



Notes from our standards body:

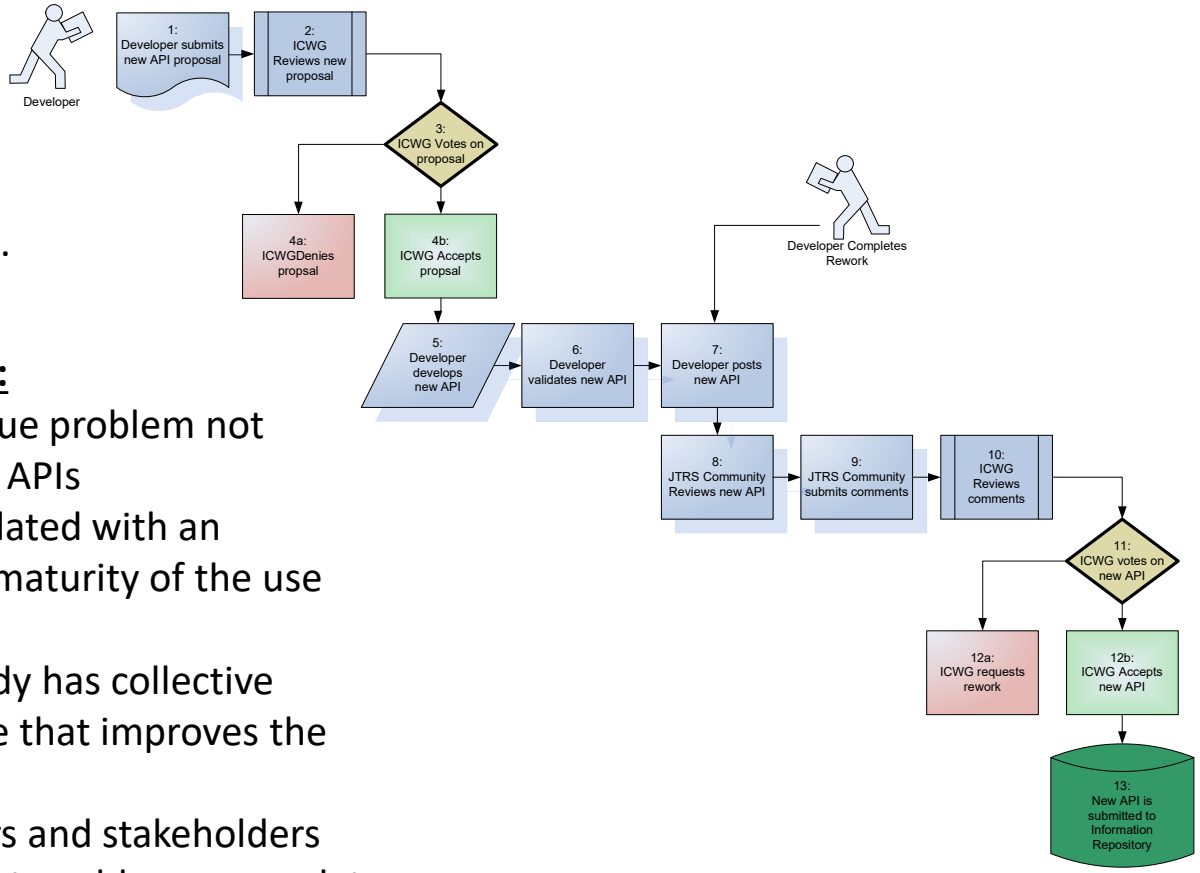
- Meeting tempo began as twice monthly, then quarterly, then bi-annually
- Provided additional value with developer education as part of the meetings
- Face-to-face meetings superior to virtual meetings
- Non-attributional meeting notes
- Helpful to have end users represented

API Approval Process

Contributors and stakeholders desire comprehensive documentation of processes (including corner cases).

This is time consuming and vexing – standards bodies are not all the same.

Original Approval Process



A few of the documented principles:

- Need – the API must solve a unique problem not currently addressed with existing APIs
- Validation – the API must be validated with an implementation to demonstrate maturity of the use cases for the API
- Collaboration – the standards body has collective experience and a knowledge base that improves the product
- Emergency Request - Contributors and stakeholders wanted a streamlined process that could accommodate an emergency request

Products and Success of the Standards Body

- 65+ Standards, APIs, and interfaces generated over a 6-year timespan
- Waveform porting substantially reduced
  - Today 50% of porting cost is testing
  - General Purpose Processor (GPP) software ports with little touch-labor
  - FPGA modem software ports acceptably within device families
- Soldier Radio Waveform (SRW) ported to 23+ radio platforms
- 39 Tactical Radio APIs and Standards registered in the DoD IT Standards Registry (DISR)
- JTNC Standards body sustaining and evolving the tactical radio APIs

Looking in the Rear Mirror

Some things we would change with today's light on yesterday's picture.

Would recommend more cautious and judicious use of component-level software communication.

- The hoped-for collection of small reusable software components was never realized

Would consider larger-module components and waveforms

- Fine-granularity of software is not the commercial model

Would define hardware waveform interfaces.

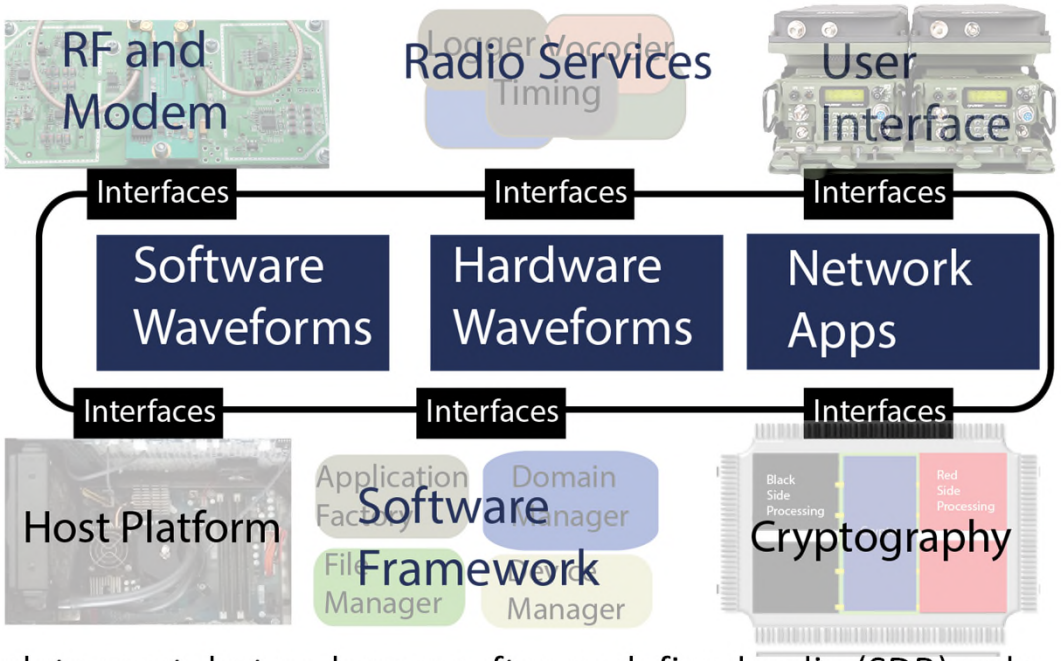
- ASIC versions of WIFI and Bluetooth make software versions a difficult cost and schedule justification
- Imperative to leverage consumer products and technology
- Emerging tactical radio model today is a hybrid of software-defined and hardware implementation

Evolution to Radio Modular Architecture

The tactical radio architecture currently fielded is missing 3 emerging features:

- Support for commercial hardware modules/ASICS
- Support for commercial waveforms
- Support for software defined networking

The Modular Radio Architecture for Tactical Radios



- Not a complete reset, but no longer software defined radio (SDR) only
- Expanded perspective includes higher-level interfaces to reuse commercial technology and components

Observations from Generating the Tactical Radio Standards

- Generating standards is not a straight line – sometimes there are curves and detours
- Balancing between excellence and ‘good enough’ is challenging
- Strong leadership above the standards body is imperative
- There must be sufficient reward for contributors and participants