ON A LOW PROFILE MAPPING OF THE OMG SOFTWARE BASED COMMUNICATIONS MODELS FOR ACHIEVING ASPECTS OF COMMERCIAL SDR

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ABSTRACT

The software communications architecture (SCA) is presently the only dominant unifying Software Defined Radio (SDR) standard. SCA commercialization is ongoing at the Object Management Group (OMG) in the form of a platform independent specification [5] for SDR communication devices. The SCA has taken a strong foothold in military circles. Though it has been argued many times that this standard may by itself not be the most appropriate one to utilize on potential private sector commercial applications and devices, it nonetheless possess formidable architectural benefits which cannot be ignored. The arguments against its use in small limited resource devices may no longer be an issue as cheaper, higher density, lower cost memory based mobile devices start to be produced. Couple this with the fact that OMG specification introduces the ability to implement the SCA using a non-CORBA based mapping and one finds that use of SCA style architectures in the commercial sector becomes a very real possibility. This paper serves to highlight some of the motivations behind potential adoption of SCA type architectures in reduced profile SDRs.

1. MOTIVATION

Examination of the OMGs PIM [5] of a software radio shows that it is an extremely rich and detailed model. In its favor are key aspects such as the fact that it does not necessarily cover solely military radios – a popular misconception given its lineage or close association with the SCA. In order to justify any motivations for providing alternative lightweight mappings of the OMGs SBC PIM it is necessary to make a cursory examination of the wireless and overall radio communications marketplace and the principal actors in that space, such as the OEMs and the pressures to which they are subject.

The technical vision for a single unifying SDR architecture to which every SDR device adheres may be unachievable. In fact the reality is and most likely will be that the different industry sectors will either produce proprietary solutions to meet their cost and time to market needs, or they may adopt partial implementations of some specifications as appropriate to their business sector. To further understand some of the possible motivations for commercial entities to adopt the use of SDR technologies,

we need to examine what potential factors affect the use of SCA or equivalent SDR middleware to commercial sectors. However, the answer is complex owing to the fact that each commercial sector's motivations are different and as a consequence the motivation for their possible adoption of SCA or PIM derived SDR middleware technologies is different. As an illustration we ask - what beneficial aspects might a typical commercial entity building radio technology based products glean from an SCA-based SDR that has been beneficial to JTRS SCA practitioners?

- ❑ Waveform portability? Unlike JTRS, the commercial sector has no plan to share waveform implementations.
- ❑ Interoperability? Possibly to a degree, but this term means different things to different industry groups in this space.
- ❑ Language independence? Not always felt relevant as C and assembler, and C++ to some degree dominate the implementation efforts today

If we look at the providers of private wireless radio home networking vendors, some will say they see benefit, but only in the context of it offering significant time to market or improved quality benefits.. Conversely other vendors report that any technology that would that help accelerate their progress towards producing their next generation products for new standards is of benefit. For example, migrating a product line to work with WiMAX could make use of these technologies in the synthesis of such platform in coming years. In other sectors, for example, the entertainment sector, the impetus to use SDR technologies in their next generation offerings comes in the form of helping produce a flexible platform to allow the rapid deployment of new and multiple product lines of wireless entertainment items. However, often such solutions tend to be proprietary as vendors are seeking to protect their investments, and market share. Here neither interoperability, nor waveform portability is sought – rather openness for the sake of deploying newer items rapidly over some pre-established base platform is the goal.

Cellular carrier's motivations are principally revenue based upon the fact that they have to recoup capital outlay and investments in the licensing of spectrum and building core networks. They are therefore motivated by forces differing from those previously presented. If OMG PIM-based SDR is to be used – it has to offer significant financial and technological benefit for these adopters. Exactly how SDR benefits the carrier's business model depends on whether we look at the terminal or the base-station provider. Commercial device architectures are highly optimized for power as in the case of handsets, or algorithmic capability and scalability which translates into the number of concurrent subscribers connected to a base-station. On the hand-set power and chip real-estate are the guiding concerns – no COTS model is adopted at present. As a result SDR technologies need to offer significant benefit within this framework in order to be of value. Adoption is possible, and is being considered in cases where handset devices may be required to be waveform heterogeneous, multi-mode, and multi-band. In the United States, for example, carriers market handsets operating in multiple GSM bands and CDMA with Bluetooth™ functionality and possibly WiFi as well.

Although the OMG-PIM model is extensive, it contains no guidance as to how one might extract specialized profiles for base-station architectures and/or that of a terminal handset. It does nonetheless provide sufficient modeling apparatus from which to build such profiles, which in itself is a significant motivator to use this as a harmonizing radio device modeling standard possibly. Present commercial standards and specifications tend to be more focused on the physical hardware (e.g. OBSAI, CPRI) or the wireless or technological standards (e.g. 3GPP, IEEE 802.x, ZigBee, etc). The OMG SBC PIM model is unique in that it provides an over-arching canonical model with which to build SDR devices and simultaneously allow conformance to the other protocol standards.

It is clear that increasingly vendors are beginning to look at software defined radio technology as a viable mechanism to save costs in manufacturing or improve time to market and quality. Even more interesting to note is that they have broadly similar notional models for the software defined radio 'platform' and the software defined radio 'waveform'. What is not commonly agreed upon is what the beneficial drivers are in those areas. So, for example, in commercial environments the model of the software radio platform may not be centered on maximizing waveform portability. Additionally, a question often asked on the hardware platform side is: what models will provide the designer with maximum portability of the software radio operating environment

(OE, a term used to describe an implementation of an SCA framework) over differing classes of radio device and to what extent portability is possible over the device's modem component. The degree to which such software is tightly bound to the hardware depends on cost and end-user requirements. Often the portability problem is two fold, seen as sort of a duality. Not only is there a desire in some industry sectors to have an OE portable over a wide class of underlying hardware platform, but also to have the software radio waveform be portable over a wide class of OE. These two aspirations are the key motivators in seeking a unifying detailed architectural model, as they provide for multiple models or profiles to be extracted in response to these requirements. What this motivation also highlights is that not only is a commonly agreed upon model necessary, but also a set of standards to protect the investment of the actors in those radio communications spaces.
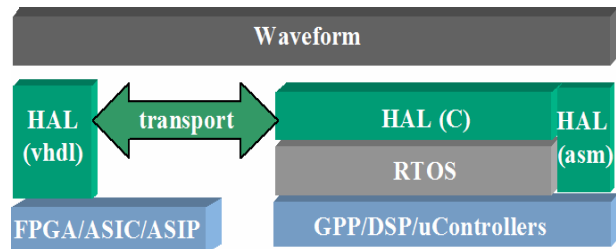

Figure 1: How a commercial vendor might map waveforms to their platforms depends on their market share and revenue motivations.

2. STANDARDS

Currently there is tremendous diversity in the marketplace in terms of communications standards. Specifically, in the commercial sector this is due to widely diverse and varying revenue models upon which services are based and deployed. There are a number of commercial and military standards in the wireless communications industry, principally dealing with the actual communications protocols and air interface used to communicate. Fortunately, these myriad standards do not prevent a natural evolution towards SDRs. As far as SDRs are concerned, these standards define waveforms (CDMA, GSM, GPRS, and EDGE), support interoperability, and define hardware architectures (CPRI, OBSAI) that are used within a total SDR solution. In fact, there is no single standard covering all aspects of building commercial SDR devices and the only standard that defines an underlying architecture for an SDR product line and is implementable is the SCA (developed for U.S. JTRS military radios). Part of the reason for this is the diversity in revenue and business model of organizations that would potentially use SDR in the current wireless world. Yet SCA presents a powerful case for adoption in the commercial world if only because of the simplicity of

the model. The model serves to decouple elements of the platform that may be pluggable, interchanged, or reconfigured during operational periods of varying length and also serves to decouple the platform from the waveform and its subcomponent elements. So although we are not making a case for abundant stringent standards, we are promoting the notion of a common model for SDR from which to take profiled mappings supporting different commercial domains. The OMG's SBC PIM presents such a canonical model that can be used to provide smaller mappings to other technologies.

3. THE OMG CANONICAL SOFT-RADIO MODEL

The OMG's "PIM and PSM for Software Radio components" is in essence the definition of a component-based architecture for SDRs. These documents are currently being voted on by the Object Management Group Domain Technical Committee within the OMG for formal adoption. The OMG's Software Radio specification is planned to be formally adopted in December of 2005. As part of this process, the OMG's Board of Directors will vote on this in December of 2005. These documents are:

☐ http://www.omg.org/docs/dtc/05-09-05.pdf

☐ dtc/05-09-02 (Software Radio FTF2 IDL file)

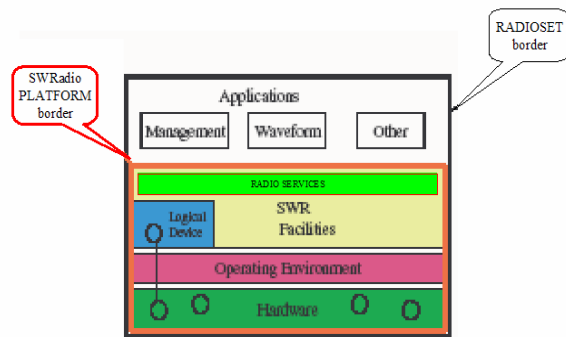☐ dtc/05-08-05 (Software Radio FTF2 XML file)

Figure 2 – SW Radio Layered View

This specification is based on SCA concepts, but extends the notional concepts beyond those of classical SCA. These include but are not limited to definitions for communication channel, communication equipment radio control facilities and so on. It also provides greater flexibility and provides for mapping into other technologies such as Java™, VHDL and RTL. The specification provides for derivations from the concepts defined in the profiles found in the specification.

4. POTENTIAL ALTERNATIVES

The work of several radio vendors resulted in the SCA specification based upon CORBA. Subsequently, their efforts at the OMG led to the SWRADIO PIM specification. However, unlike the military radio vendors and the JTRS efforts, the commercial world currently has no single unifying specification that defines in a complete overarching architecture needed to support a common radio middleware. Nor does it have a model and standard for a software-based waveform; therefore what is clearly lacking is a unifying framework.
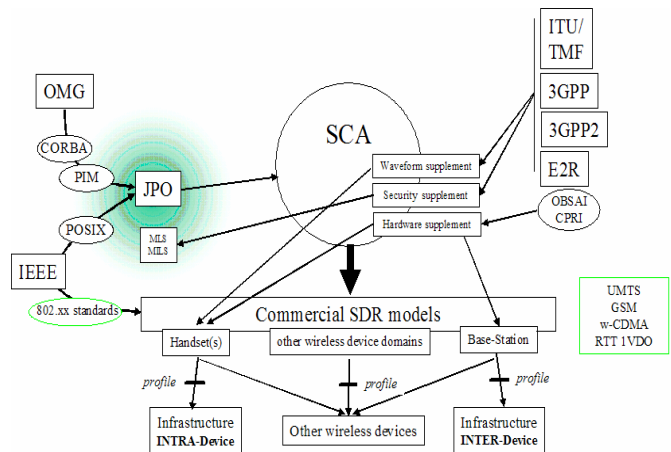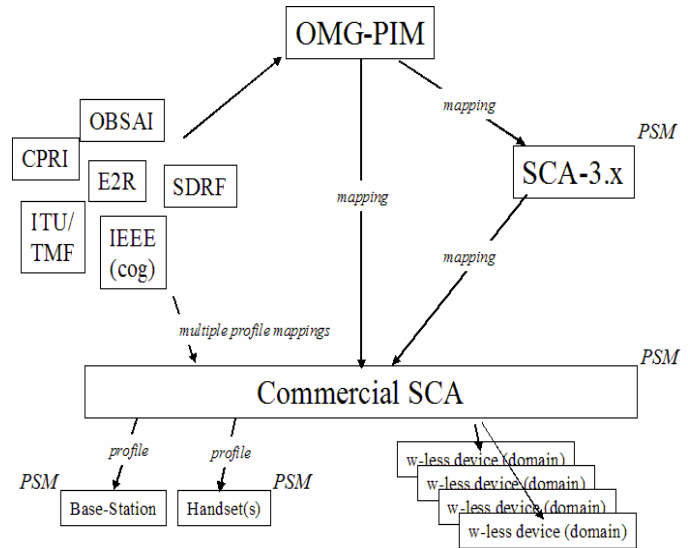

Figure 3 & 4 – Derivation of alternative models

However, the members of the OMG, SDR Forum, and other bodies such as E2R are making significant headway in this area. The efforts from these groups are leading to:

☐ A model for commercial SDR deriving from the OMG PIM model – Creating possibly a sub-profile specializing base-station and handset frameworks.

- ❑ A base-station profile built upon and using OBSAI, CPRI, and E2R standards and adhering to the base-station framework. This would help create specializations. Here we could also draw from work done by the SDR forum and JTRS JPEO.
- ❑ A handset profile emphasizing low power and minimal chip real-estate supporting not only waveforms but an entire underling handset framework.
- ❑ Models of a waveforms and platforms derived directly from executable design models.
- ❑ Models based on domain specific profiles of RF devices.

One of the tenets of SCA is that it provides a way to portably load and unload waveform media in software on the device. So these SCA compliant waveforms need to be built to standards at (a) the air interfaces and (b) the OE interfaces whatever form they may take (e.g. an SCA core framework via CORBA IDL). This is a powerful notion that would be needed in any alternative model as well as it is one of the cornerstones of the software radio ideology.

It is interesting to note that there are schools of thought dealing with alternative models for implementing SDRs. They emphasize OEs and software radio waveforms and prescribe multiple waveforms running simultaneously and optimally sharing resources on the radio platform[1].

Presently, an SCA core framework, or more precisely the an implementation derived from the SWRADIO PIM, provides for a number of useful attributes that any low profile alternative mapping would need to provide. Chief among these are:

1. Waveform portability
2. Platform HW & OS independence
3. Componentized reusability
4. Reduced integration times of components
5. Full lifecycle control of s/w artifacts at deployment and runtime
6. Generic resource management
7. Generic device management
8. Configuration and deployment management
9. A framework for integrating logical and physical radio entities.
10. Interconnection and intercommunication within the radio.

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[1] It is interesting to note that the SCA specification does not preclude such waveform synthesis, though it has not been seen commonly in implementations to date.

11. Descriptors supporting different radio application domains.
12. Security.

Commercial developers of wireless products and technologies view this list differently. The commercial checklist is typically comprised of the following, but the items marked with a check rank higher for these commercial sector practitioners.

- ☐ Waveform portability.
- ☐ Language independence.
- ☐ Platform H/W & OS independence.
- ☑ Reuse and reusability
- ☑ Reduced integration times of components
- ☐ COTS model driven
- ☑ full lifecycle control
- ☑ Generic resource management
- ☑ Generic device management
- ☑ Configuration and deployment management
- ☑ A framework for integrating logical and physical radio entities in an OO manner
- ☐ Interconnection and intercommunication within the radio
- ☐ Descriptors
- ☐ Security

5. ADDITIONAL FACTORS

Commercial practitioners have extended the list to include:

- ☑ Power
- ☑ Long term memory management
- ☑ Generic processor resource management
- ☑ Waveform specialization whilst keeping within an open framework
- ☑ On-line upgrade/updates
- ☑ Vendor specialized plug-in framework
- ☑ Effective Scheduling and Synchronization

6. CONCLUSIONS

Models and specification for the low profile commercial SDR can be effectively provided by leveraging the OMG PIM and profiling it appropriately. In addition, there are new models for defining commonly used waveforms and standards such as CDMA, w-CDMA, GSM via the work of groups such as E2R. Furthermore, working from commercial specifications to integrate base-station equipment architectures and using the OMG's PIM-PSM model is a viable prospect. An SDR architecture derived from the OMG PIM, using appropriate middleware technologies, is a possible solution. Such a framework must also model and incorporate aspects for control of

power, CPU consumption, smart antennas, and adaptive location based cognition.

In the final estimation we ask what might motivate a mapping of the OMG PIM to produce smaller profile specifications for different classes and domains of current commercial radio communications domains. This can only come about if there is a rapid evolution of SDR platforms that can cater to a wide range of commercial waveform application media – through such activities will come the motivations. One question being asked is if using an SDR platform will help vendors build more spectrally efficient devices? Or could SDR platforms help promote spectrum sharing technologies presently coming to the fore. Maybe the FCC policies can stimulate the rapid uptake of SDR technology based device designs.

What is clear is that accelerated evolution of SDR devices and their increasing role in society's day to day activities will help stimulate the creation of profiles from the SWRADIO PIM as the desire for interoperability and portability increases. The need for a standard, overarching, and unifying model will only come about when such SDR devices begin to make increasingly greater contribution in our everyday lives.

7. REFERENCES

[1] Mitola J., – *Software Radio Architecture – Object oriented Approaches to Wireless Systems Engineering*, Wiley 2000.

[2] Reed J.H., – *Software Radio, A modern approach to Radio Engineering*, Prentice Hall 2002.

[3] Raisanen A.V. et al., – *Radio Engineering*, Artech 2003.

[4] Proakis J.G., – *Digital Communications*, McGraw Hill.

[5] OMG. *Specification for Software based communications architecture – PIM and PSM for Software Radio Components*. http://www.omg.org/docs/dtc/05-09-05.pdf, dtc/05-09-02 (Software Radio FTF2 IDL file), and dtc/05-08-05 (Software Radio FTF2 XML file).

On a Low Profile Mapping of the OMG Based SBC Models for Achieving Aspects of Commercial SDR
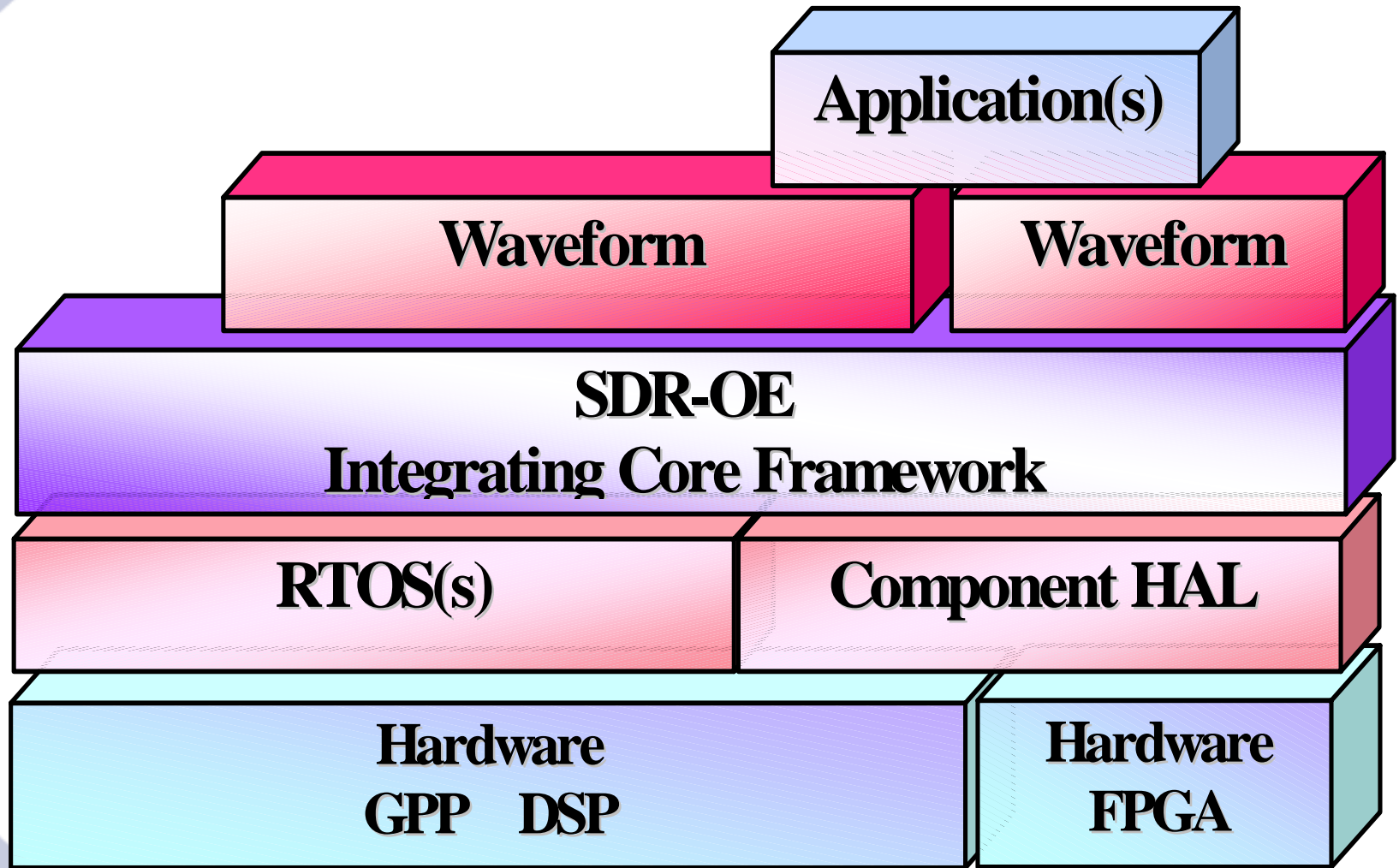
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PrismTech Corporation

Agenda

1. Motivation for alternate mappings from the OMG SBC model for the commercial SDR domain

2. OMGs canonical SBC model specification

3. Potential alternative models

4. Driving forces and incorporation from other models

5. Contrasting with full SCA

6. Conclusions

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1. Motivation for alternate mappings from the OMG SBC model for the commercial SDR domain

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▸ Technical SBC Vision – One possible blueprint of a Commercial SCA implementation

▸ <u>The SBC soft 'platform'</u>
In commercial environments is t*he model of the soft radio platform centred on maximizing waveform portability ?*

▸ <u>The SBC 'waveform'</u>
What are the possible models of the canonical communications medium which is universally portable over some soft platform – what is the equivalent of the <u>duality problem</u> in the commercial world ? Indeed does the duality problem even exist in the commercial domain ?

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pure canonical signal processing chain of SDR device

Core Framework

POSIX

POSIX

GPP

DSP

COTS board

MODEM

Switch fabric/RapidIO ..etc

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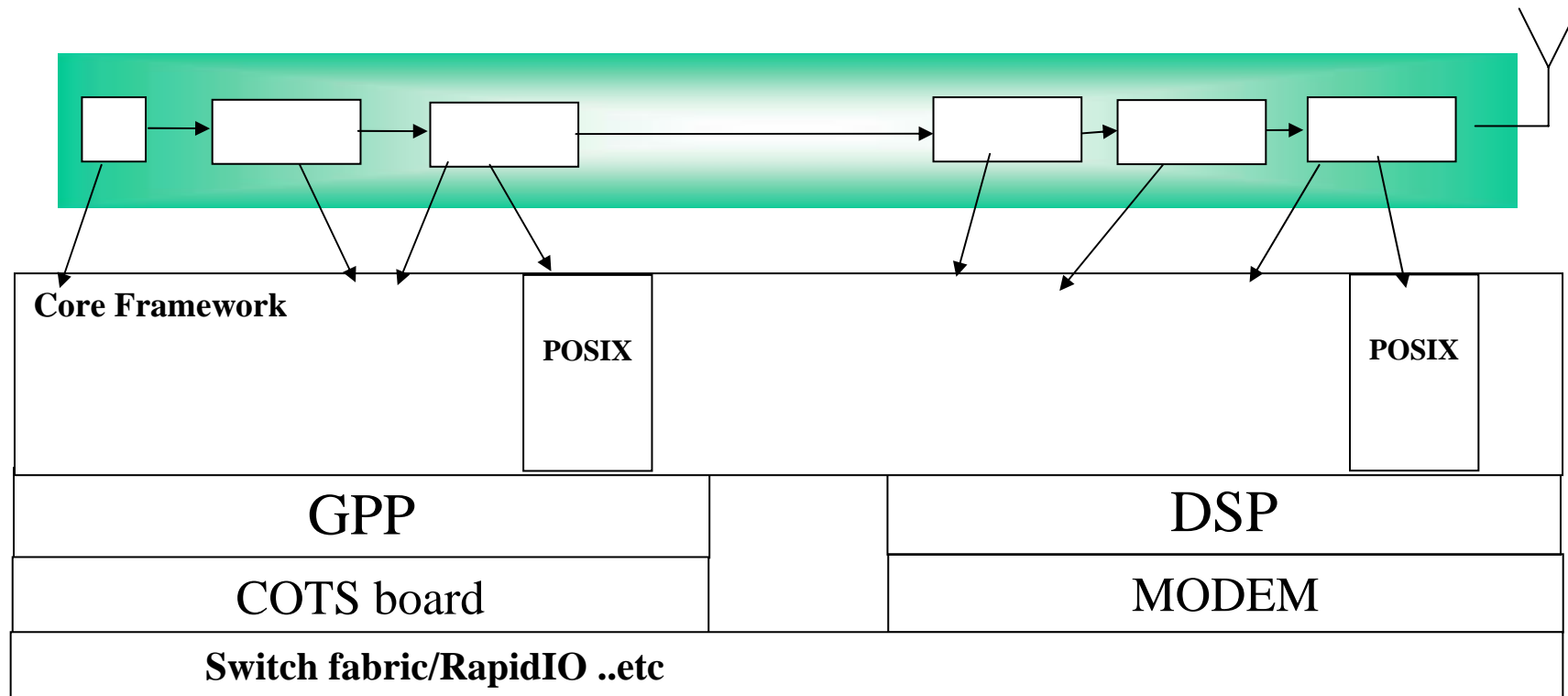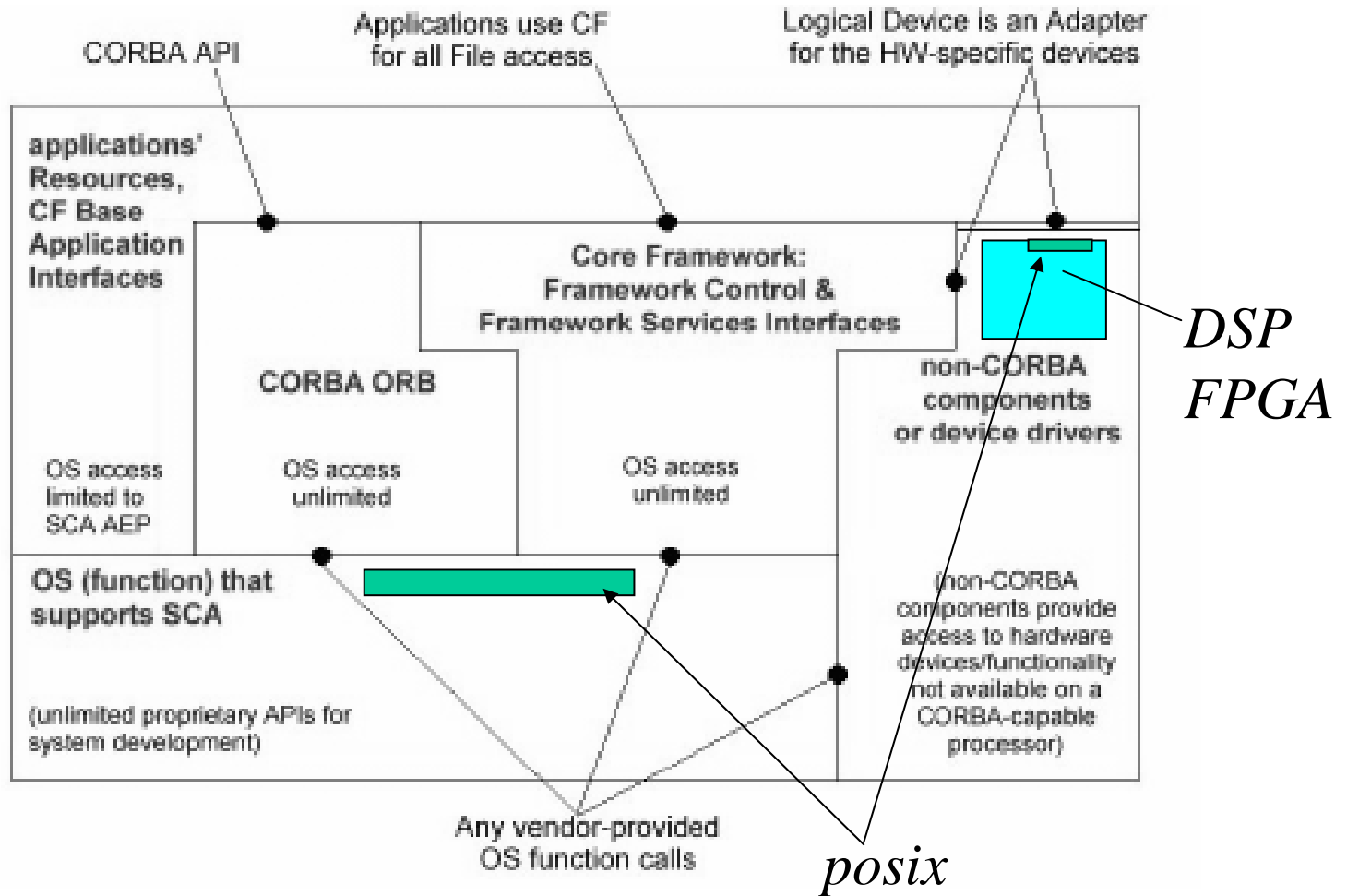
- Cellular Carriers
- Home networking vendors (LinkSys, …)
- Wireless backhauls for enterprise (Strix-systems…)
- Emergency services (E911, fire, police, ambulance)
- Leisure/entertainment – FCS radios
- TV/Cable/information media – (SDR forms of HDTV)
- Leisure/entertainment – *content based delivery.*
- Other smallers groups (RFID, vehicle tracking, GPS centric location based services)
- Automobile and telematics industry use of RF
- Instrumentation manufacturers.

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Commercial motivation for SDR models

▸ Commercial sector is much more diversified and the business models are very different.

▸ Certain commercial sector in the USA currently are modeling their SDR devices a little different also – more hardware centric view and see bit-streams flowing through the device, rather than a canonical software architecture.

▸ xHALs are common architectures, so views of commercial potential SDR devices look like …

▸ Not sure it SCA is necessarily the answer..

….SDR Forum members

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▸ Lets examine what potential factors affect the use of SCA or _equivalent SDR middleware_ to commercial sectors

▸ The answer is complex owing to the fact that each commercial sectors motivations are different to those of any other – as a consequences the motivation for their possible adoption of SCA like SDR middleware technologies is different

▸ What would a typical commercial cross-section of potential SCA SDR want that JTRS based SCA models has shown ?

 ▸ Interoperability ? …. Means different things to different groups of individuals.

 ▸ Language independence not always felt relevant.
  ▸ C and assembler dominate

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▸ What would a typical commercial cross-section of potential SCA SDR want that JTRS based SCA models has shown ?

    ▸ Private home networking vendors don't necessarily want SDR right now - but are interested in anything that helps accelerate them migrating to a WiMAX platform. Can SCA-esque platforms help in the to roll out on by 2005/6.

    ▸ Entertainment sector sees benefits in SDR and SCA like platforms to roll-out wireless entertainment items – BUT they tend towards proprietary solutions – waveform portability not a concern

    ▸ Carriers are motivated by MOU and Churn…
        ▸ How does SDR and SCA help ?
        ▸ Answers are different for the base-station and the handset side

▶ Commercial architectures are highly optimized for power, algorithmic capability and scalability (number of concurrent subscribers) concerns on the base-stations. On the handset its all about power and chip real-estate – no COTS model is adopted at present ….

▶ Power, and form factors tends to guide design

▶ There is currently no distinguishing guidelines between an SCA based SDR solution for
- ❑ the base-station
- ❑ the handset/terminal
- ❑ OMGs PIM/PSM does however address this SCA shortcoming though … more to come.

▶ Commercial specifications currently more focused on the physical hardware e.g.
- ❑ OBSAI
- ❑ CPRI, E2R

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2. The OMGs Canonical SBC soft-radio device model

- *Platform independent model (PIM)*
- *Platform specific model (PSM)*
- *…. and its mappings*

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External client calls software radio infrastructure to request the services of a waveform application
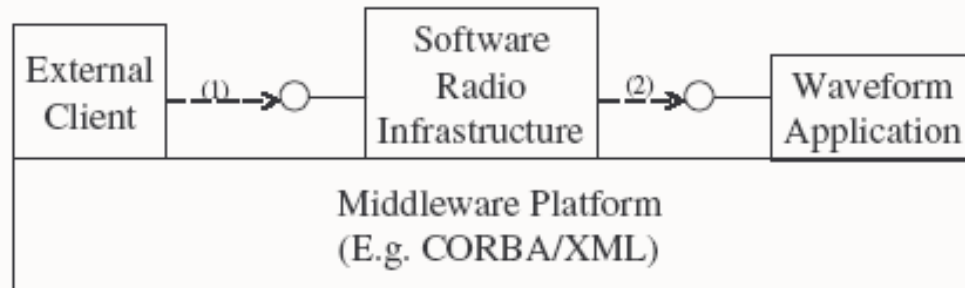
(1) External client calls software radio infrastructure to request the services of a waveform application
(2) Infrastructure calls waveform application to request initiation

Model of interaction of External Client, Radio Infrastructure, and Waveform Application
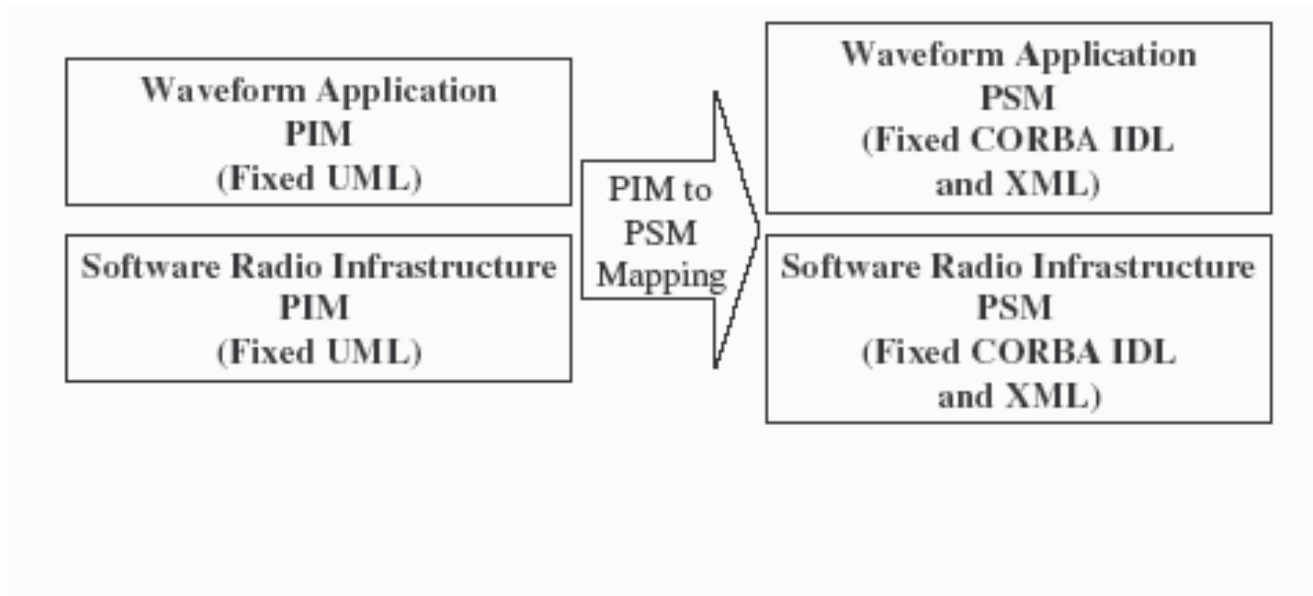
Deriving the Fixed CORBA IDL and Fixed XML from Fixed PIMs

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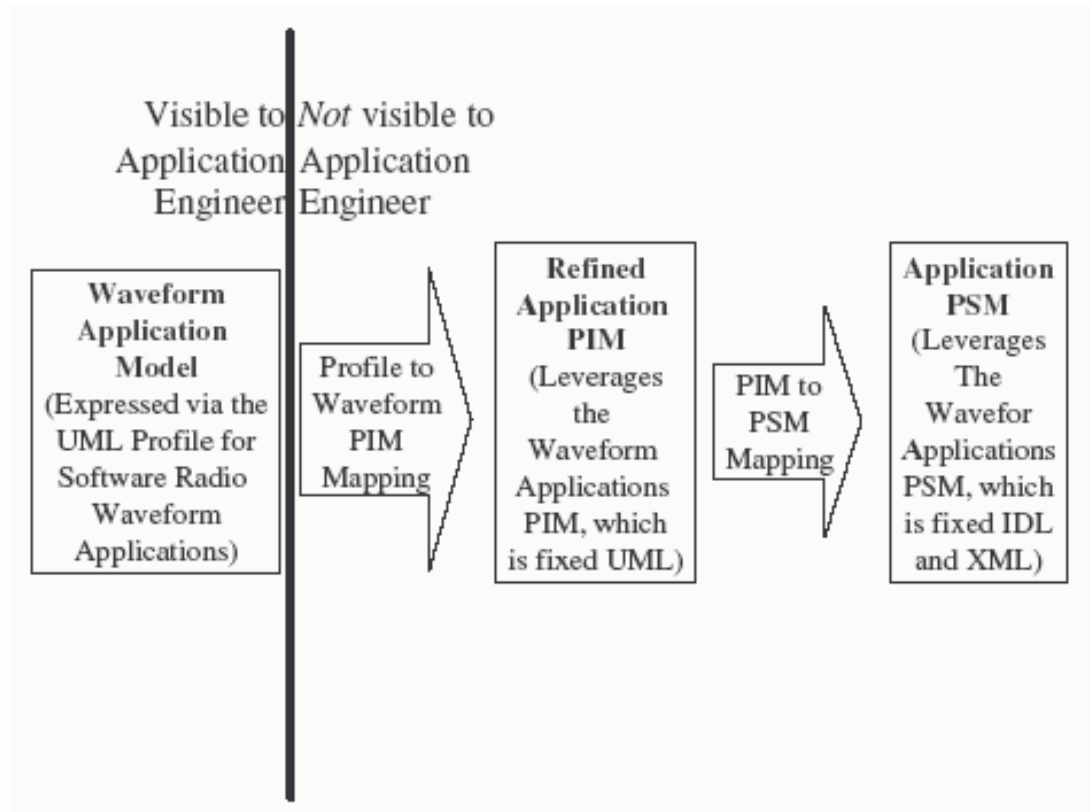
Mapping Transitively applied
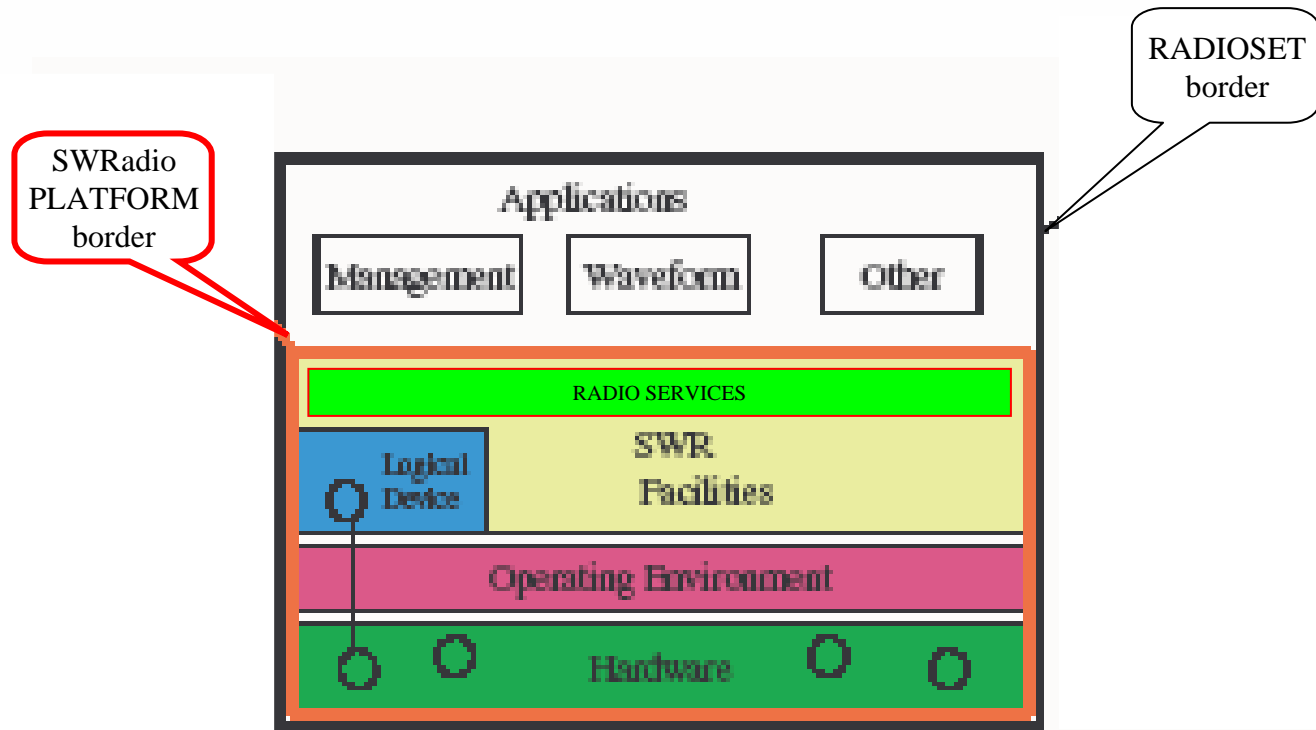
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SW Radio Layered View

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3. Potential alternative models

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▸ Unlike JTRS the Commercial have no single specifications that defines in a complete overarching specification

  ❑ a CORE framework middleware (based on CORBA or not)

  ❑ a waveform in terms of such middleware structure (in CORBA)

▸ But the SDR Forum and bodies such as E2R are making significant headway in making those advances and one possible set of answers could be:

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▸ A model for commercial SDR that derives in part from the OMG PIM model and provides a new mapping that takes from SCA – creates possibly an SCA sub-profile that specializes base-station and handset.

▸ Base-station profile would build upon and use OBSAI, CPRI, and E2R thinking to help create specializations. Here we would also use the SDR forums and JPOs specialist HAL specifications.

▸ Handset profile would be created from exiting design models but with a view to supporting not only waveforms but applications also, but with a more mobile terminal device centric model.

▸ SCA reduced code (lower amount of CORBA code generation)

▸ E2R based models – rich detail oriented for the operators

▸ Models of a waveform and platform derived directly from executable design models like Matlab-Simulink.

▸ Models based on domain specific profiles of RF devices e.g. RFID applications.
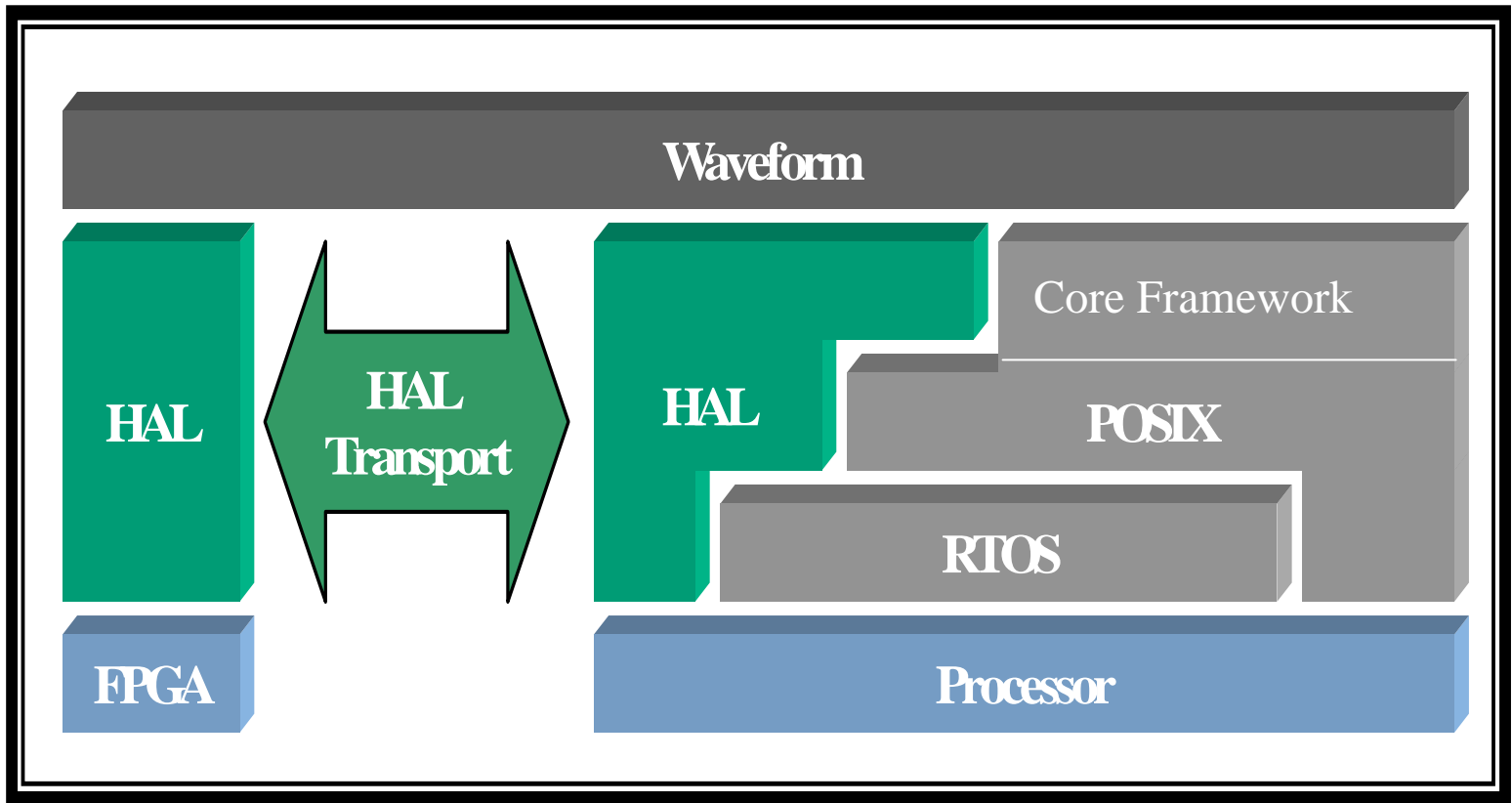
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From - Fette B., General Dynamics Recommendation to JPO on Hardware Supplement

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From - Fette B., LaMacchia M , Christensen E.,– *High Performance Software Radios, April 2004.*

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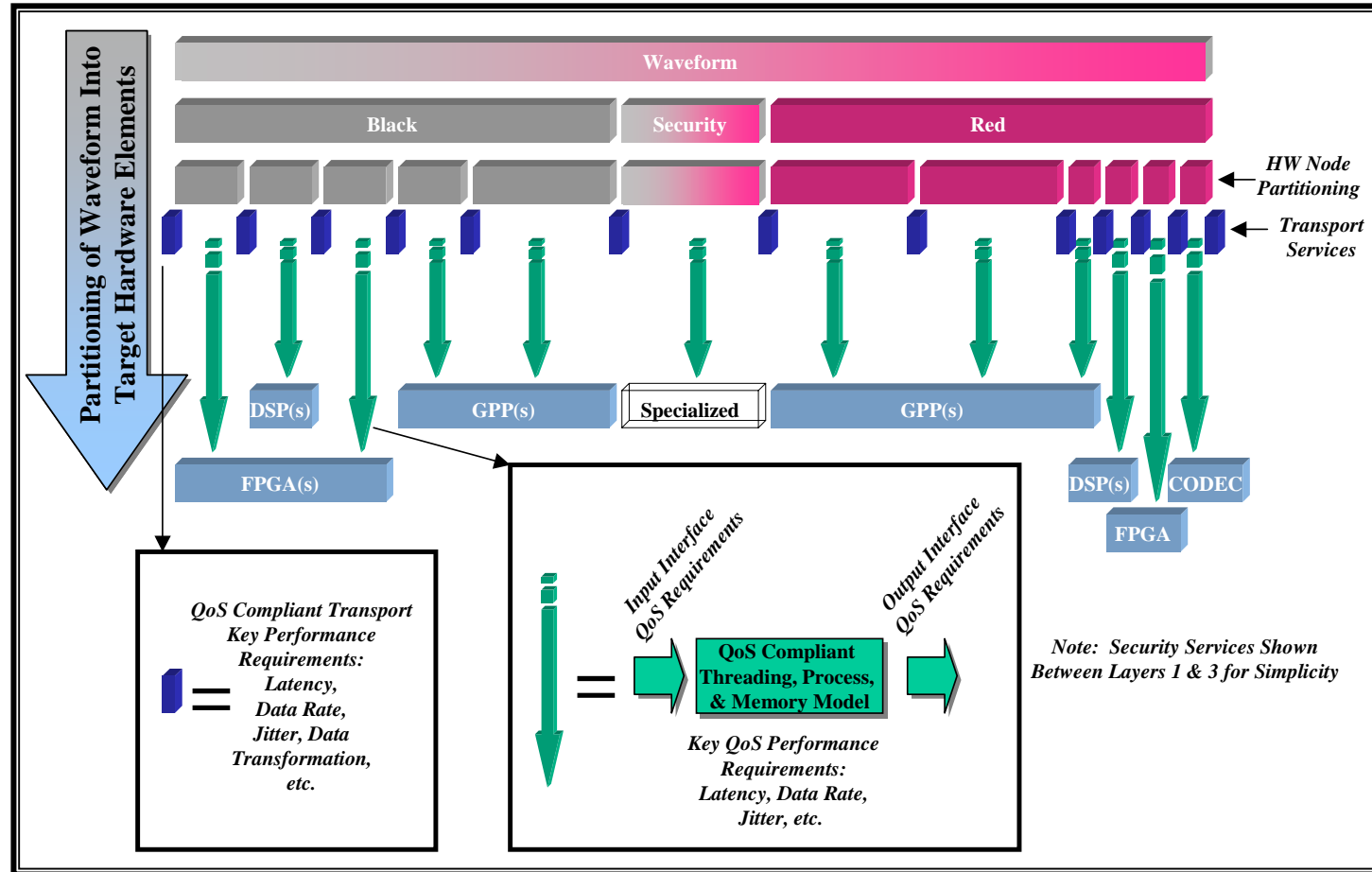
Model for a simpler commercial SDR models

Waveform-1   **Waveform-2**   **Waveform-3** **Waveform-4**

SBC profiled SDR 'machine'

FPGA/ASIC/ASIP/   GPP/DSP/ RF FE

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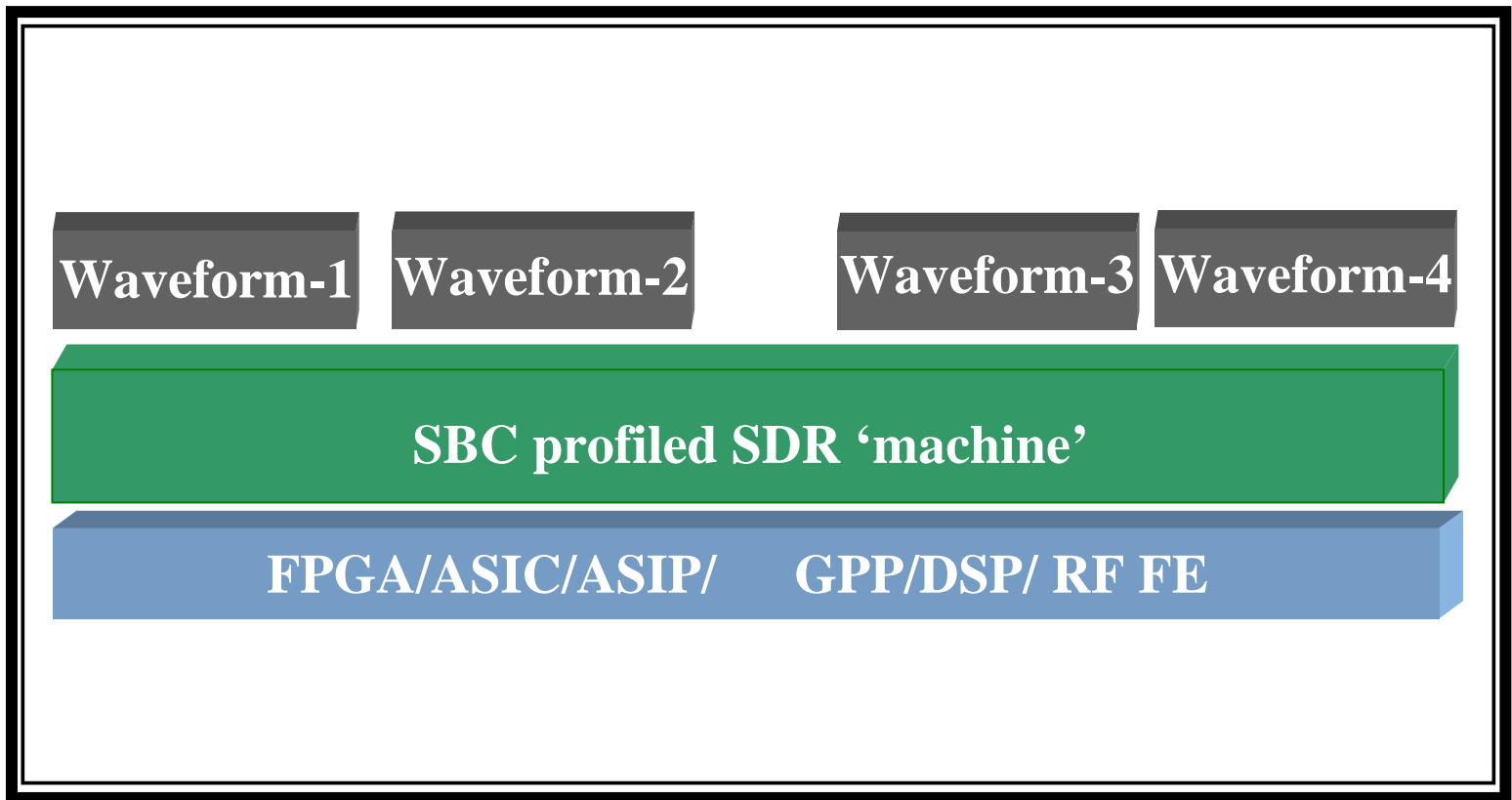
Low profile SBC mapping for Commercial SDR

▸ Recall that SCA provides a way to portably load and unload waveforms.

▸ Waveforms are built to standards at the air interfaces and in terms of being mapped to the SCA CF via CORBA idl merely to define the interfaces <u>BUT Not necessarily use an ORB though – why ?</u>

▸ <u>Waveforms can optimally share resources on the radio in time and space</u>

▸ An SCA Core framework provides for and any low profile mapping would need to provide :

  ▸ Waveform portability to some degree
  ▸ Platform HW & OS independence.
  ▸ Reuse and reusability.
  ▸ Reduced integration times of components and so faster time to market.
  ▸ Full lifecycle control.
  ▸ Resource management.
  ▸ Device management.
  ▸ configuration and deployment management.
  ▸ A framework for integrating logical and physical radio entities in an OO manner.
  ▸ Interconnection and intercommunication within the radio.
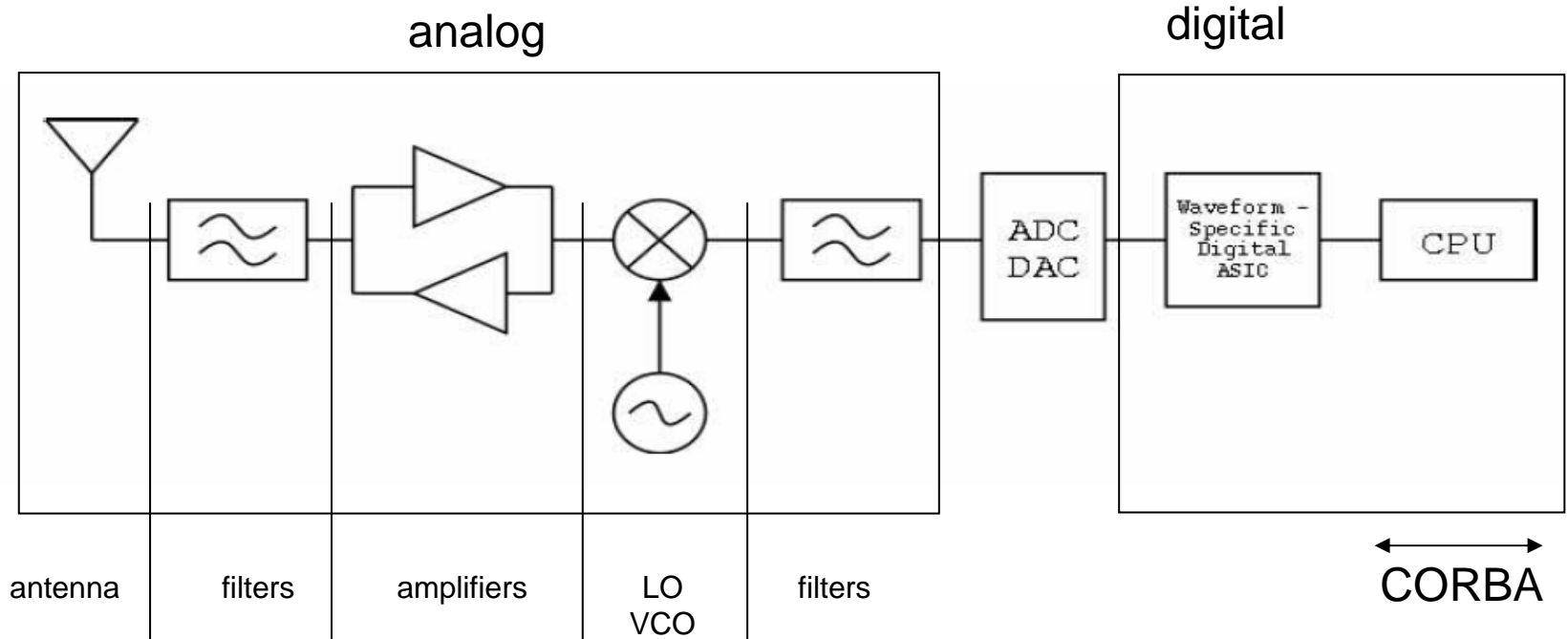 ▸ Domain profiles specializability for different domains of radio applications
  ▸ Security

▶ Commercial Checklist -
  - ☑ Waveform portability.
  - ☐ Language independence.
  - ☑ Platform H/W & OS independence.
  - ☑ Reuse and reusability.
  - ☑ Reduced integration times of components and so faster time to market.
  - ☐ COTS model driven
  - ☑ full lifecycle control
  - ☑ resource management
  - ☑ device management
  - ☐ configuration and deployment management.
  - ☑ A framework for integrating logical and physical radio entities in an OO manner.
  - ☐ interconnection and intercommunication within the radio.
  - ☐ domain profiles.
  - ☐ Secure separation via RB model and crypto

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analog

digital

| antenna | filters | amplifiers | LO VCO | filters |

CORBA

From GNU Radio

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digital

SCA & CORBA
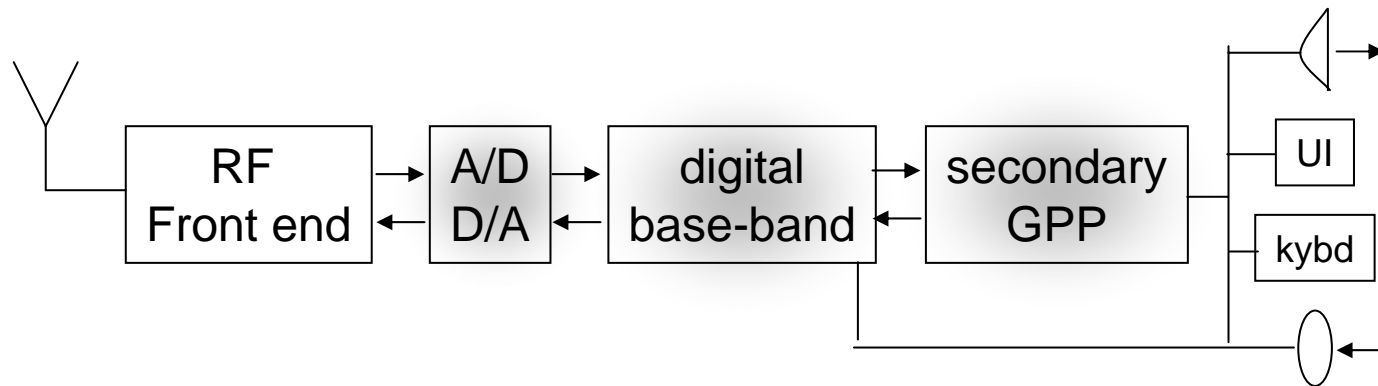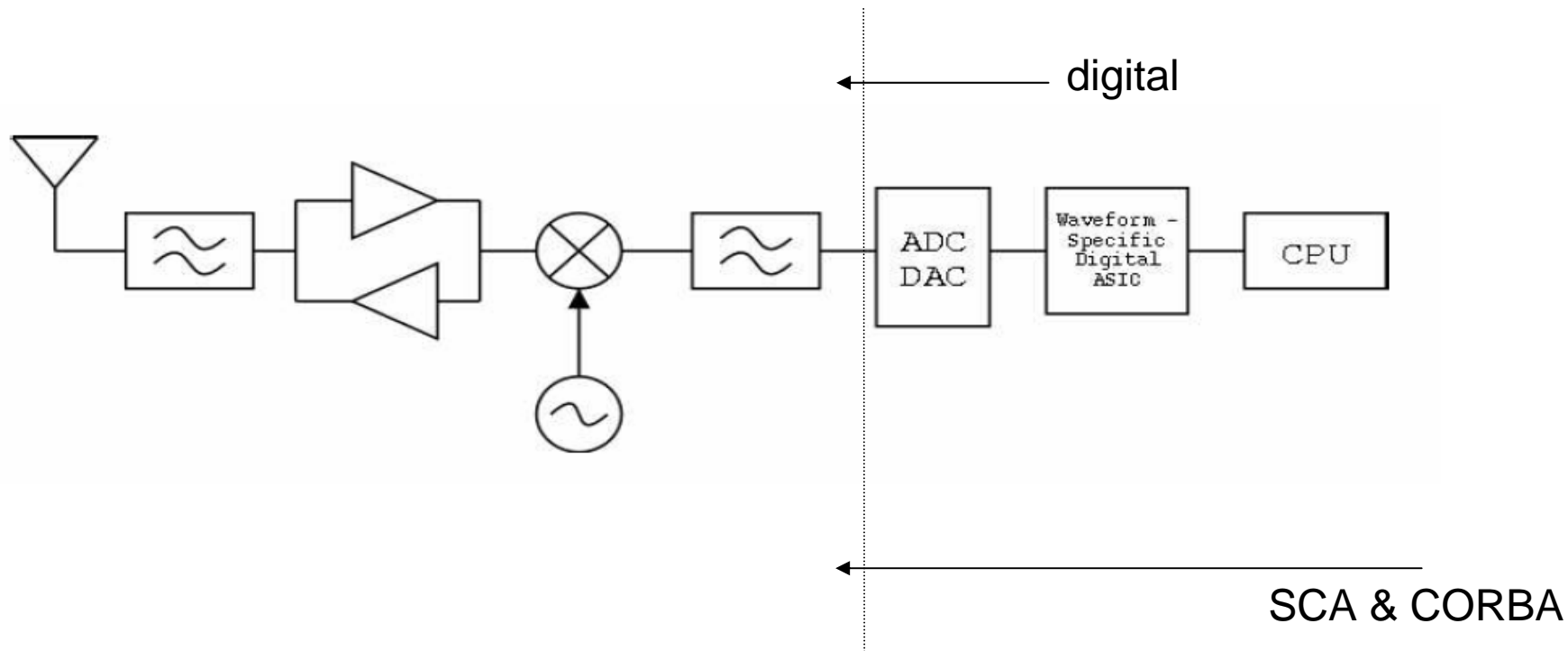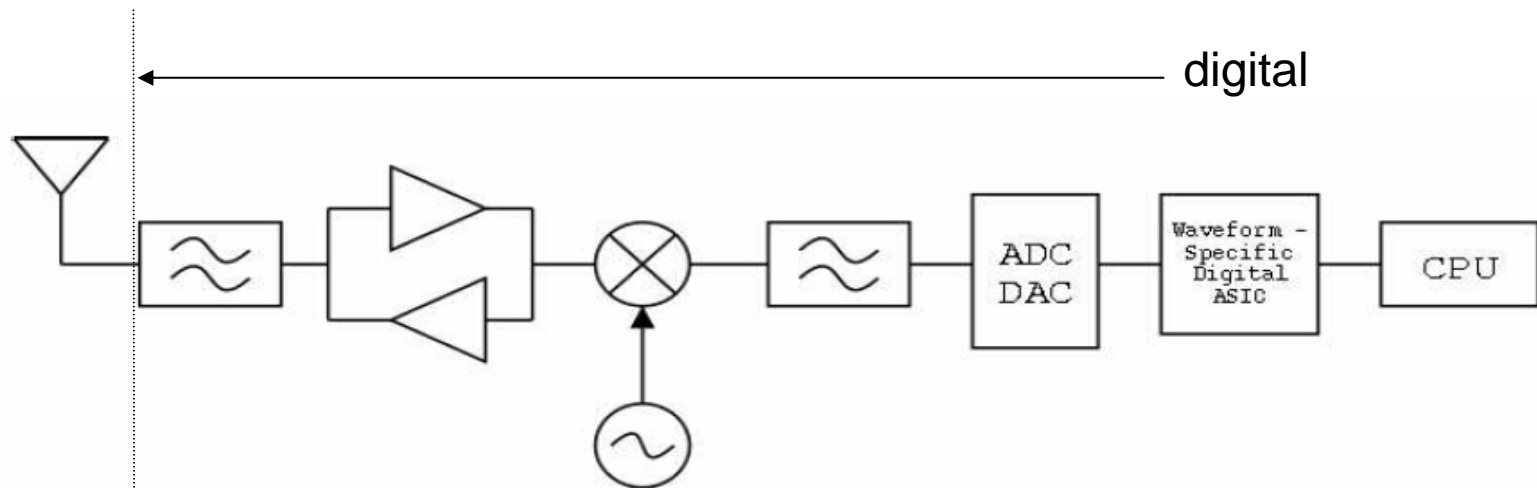
digital

using next generation digital front end processors
Software based control of device

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from GNU Radio

digital

SOFT
Waveform
GSM/CDMA

ADC DAC

CPU

DSP   FPGA   GPP
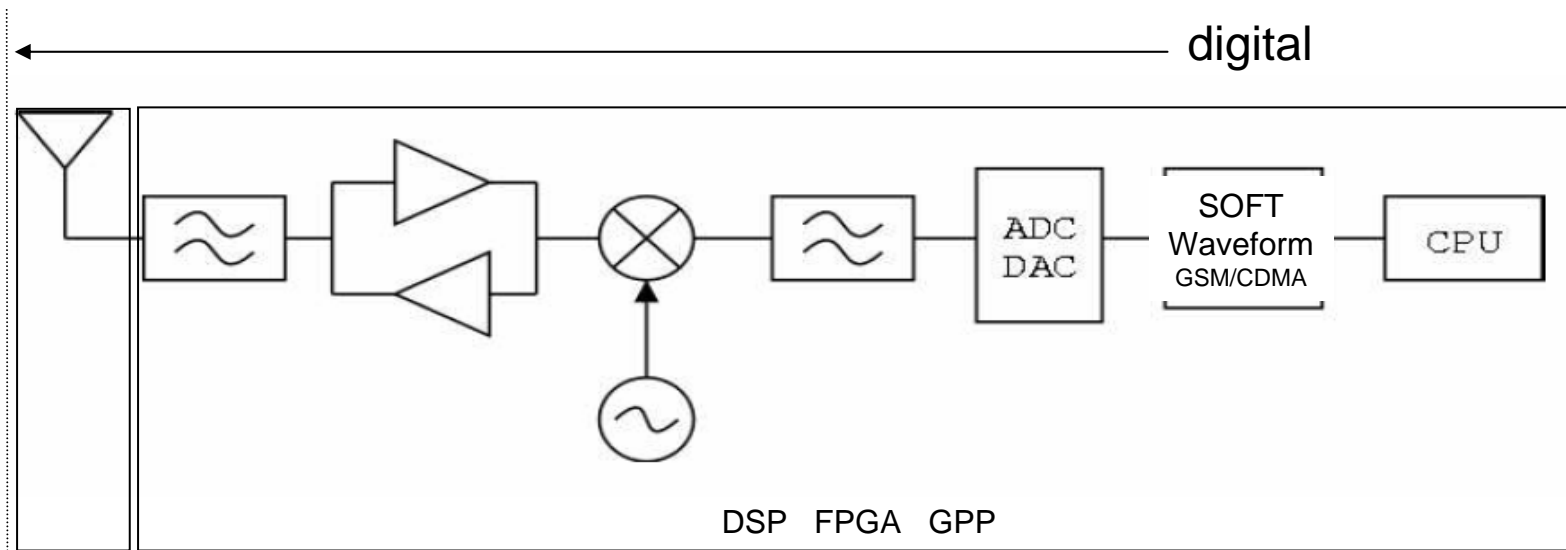
Low profile SBC core framework needs to cover varying degrees
of this device

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4. Driving forces and incorporation from other models

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▸ How might a model be derived - what might a possible model of Soft-radio devices for the commercial sector look like.

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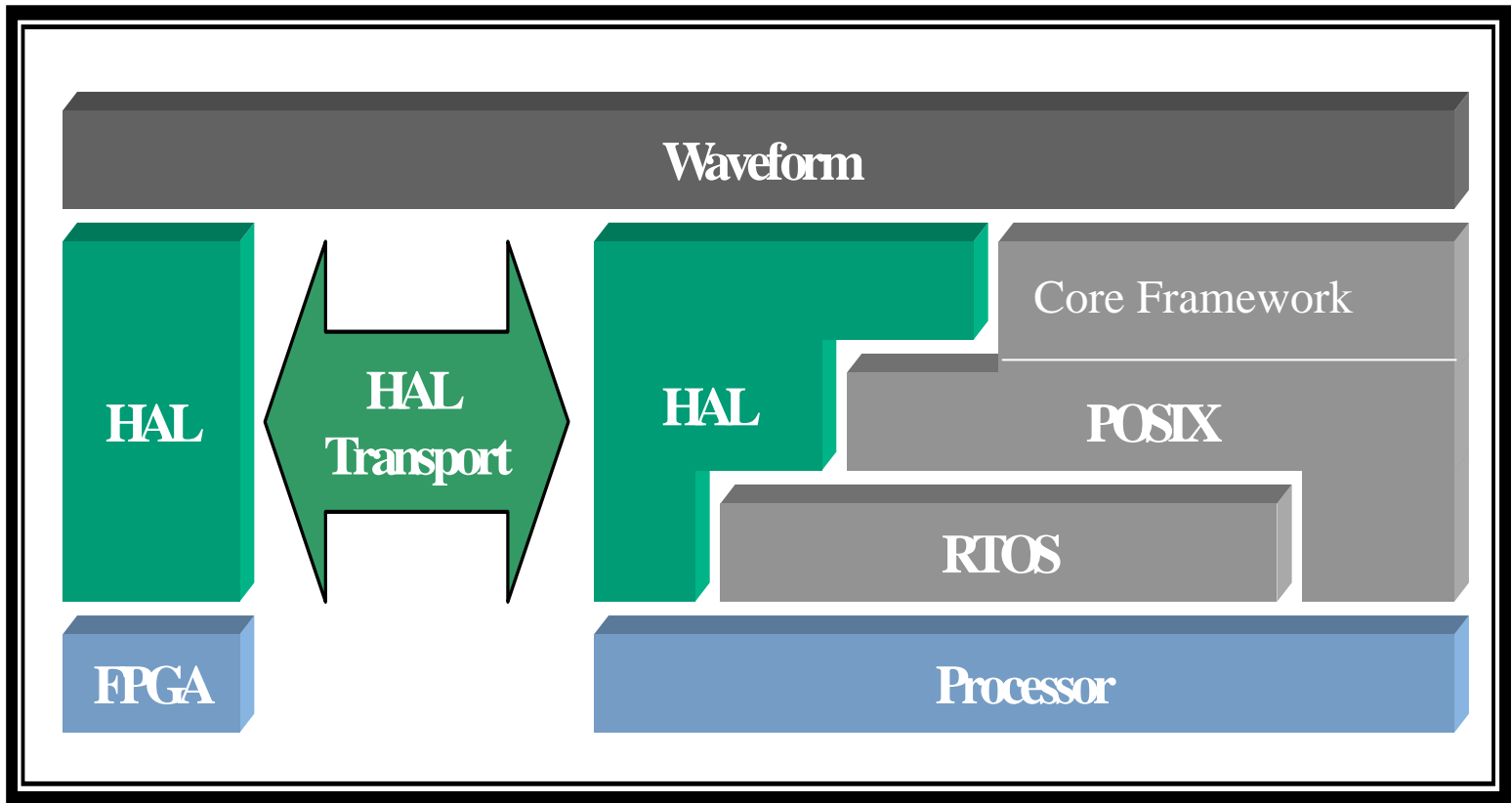**Productivity Tools & Middleware**

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Productivity Tools & Middleware
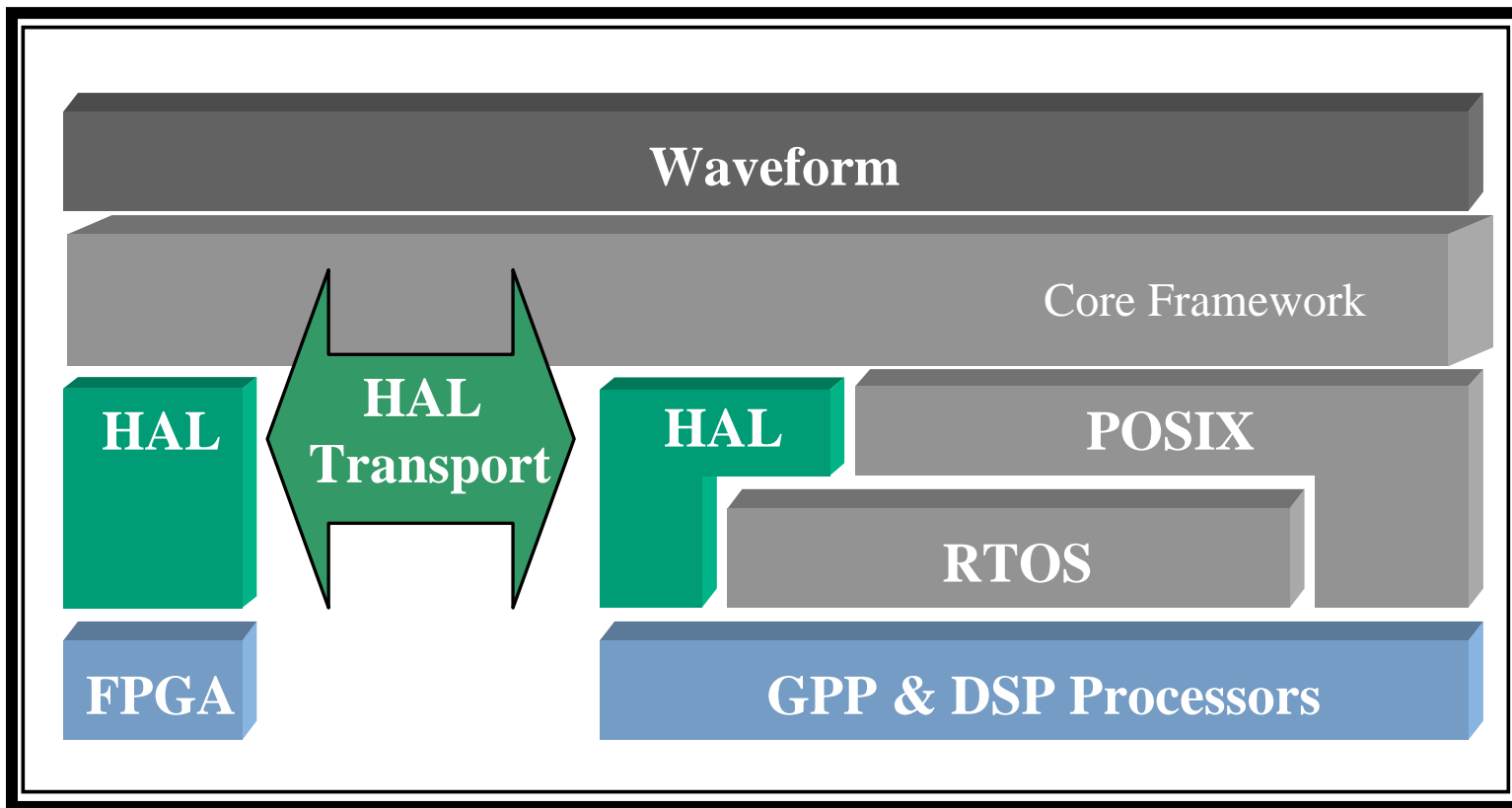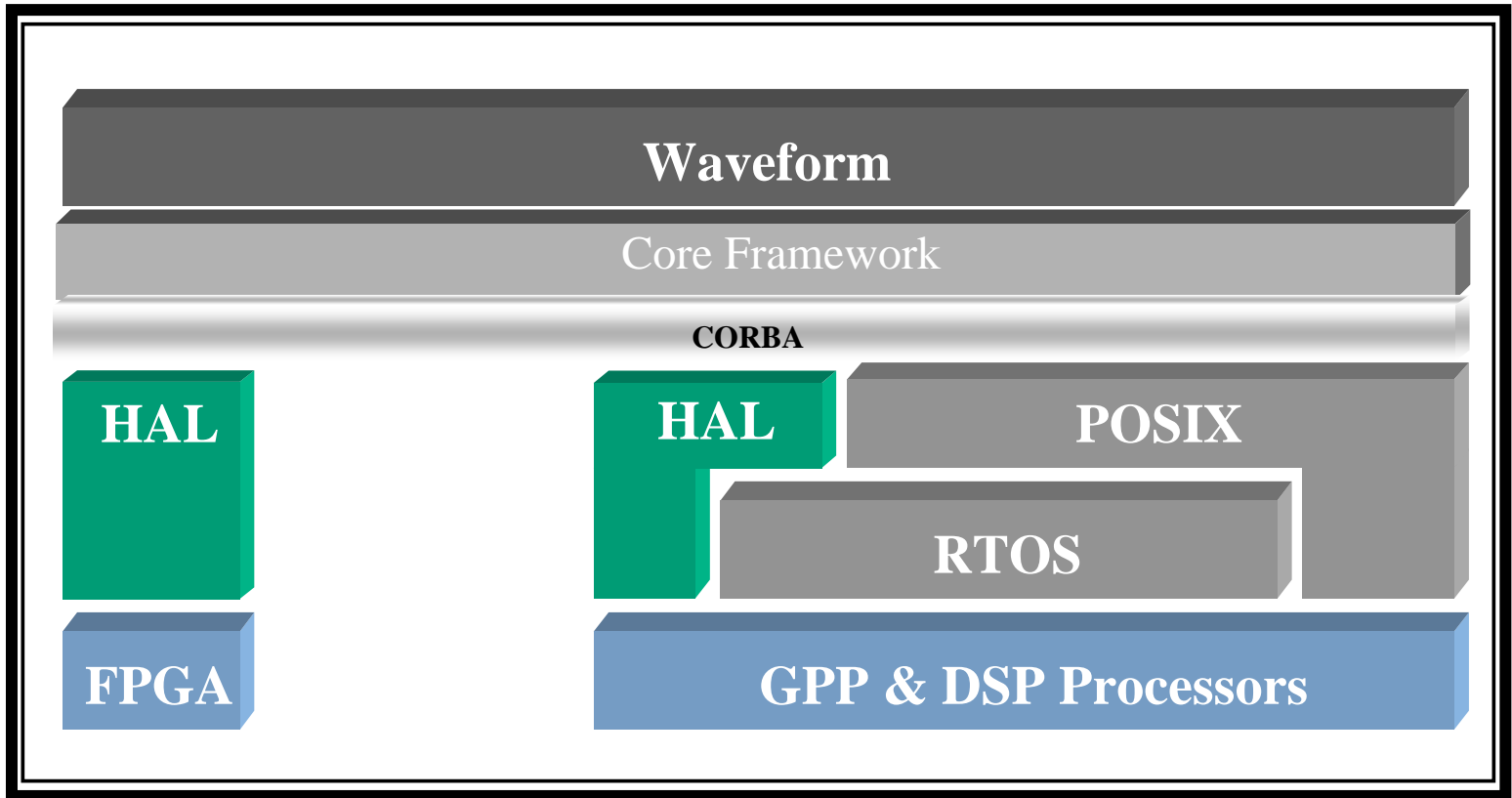
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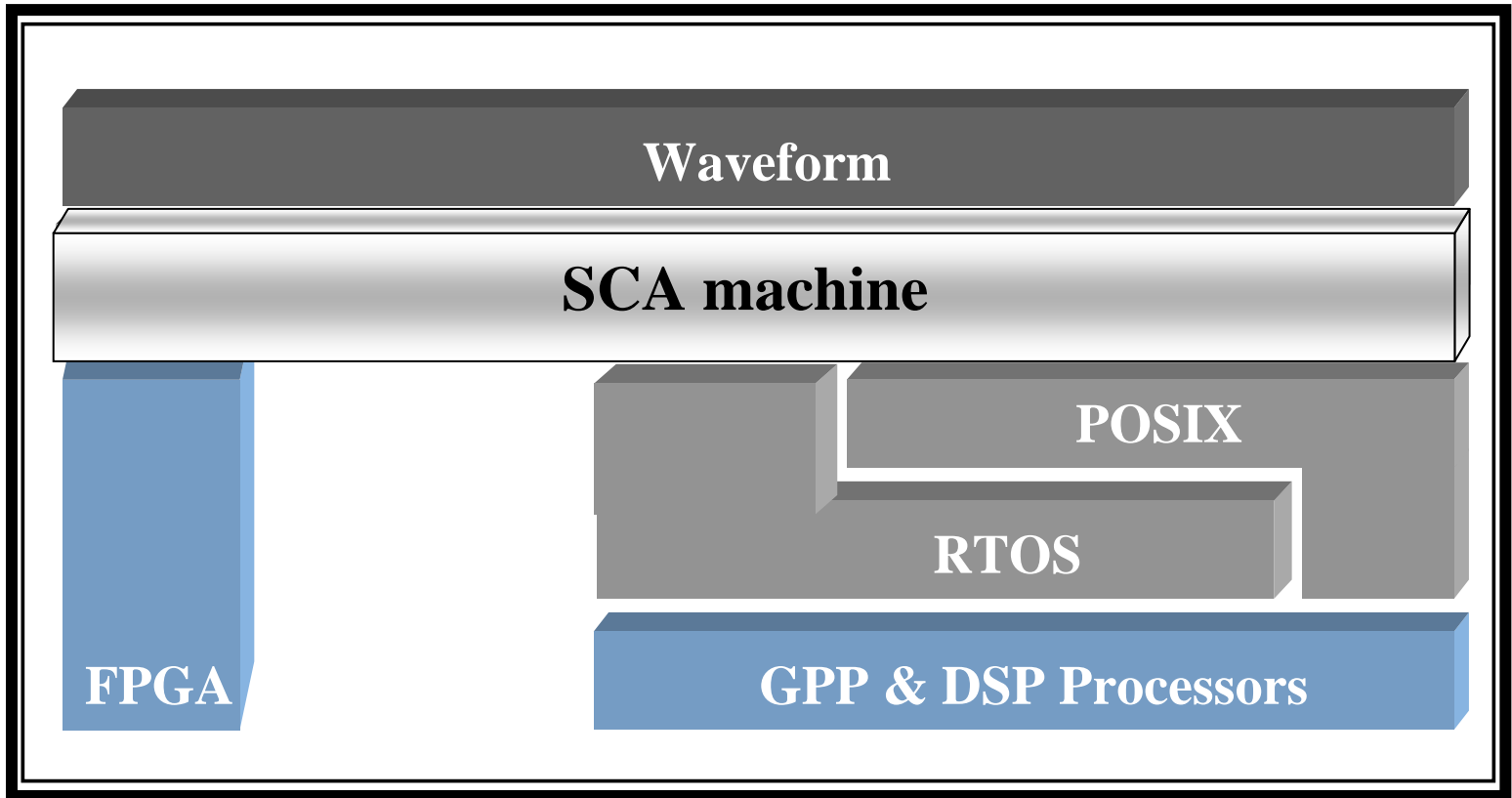**Productivity Tools & Middleware**
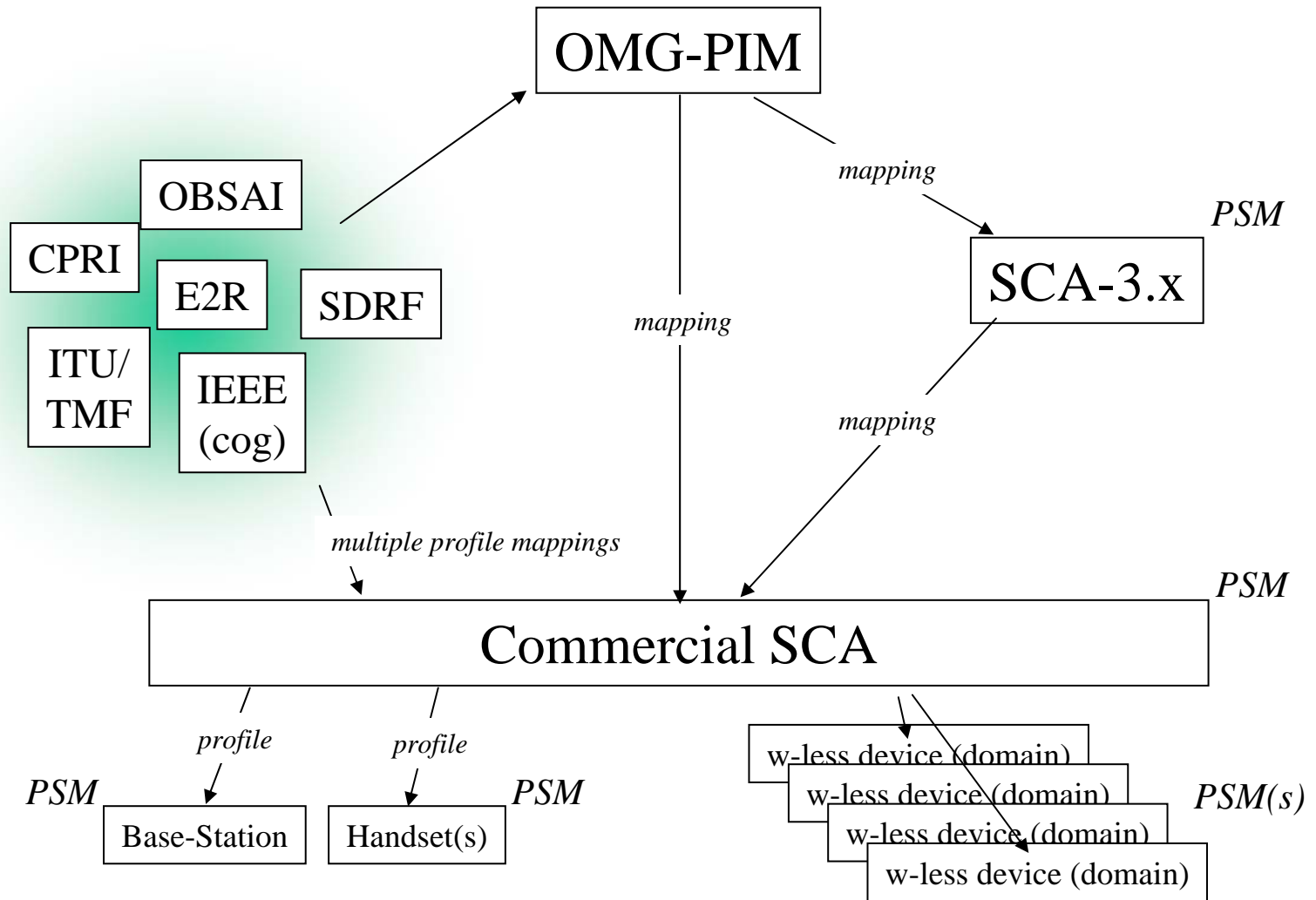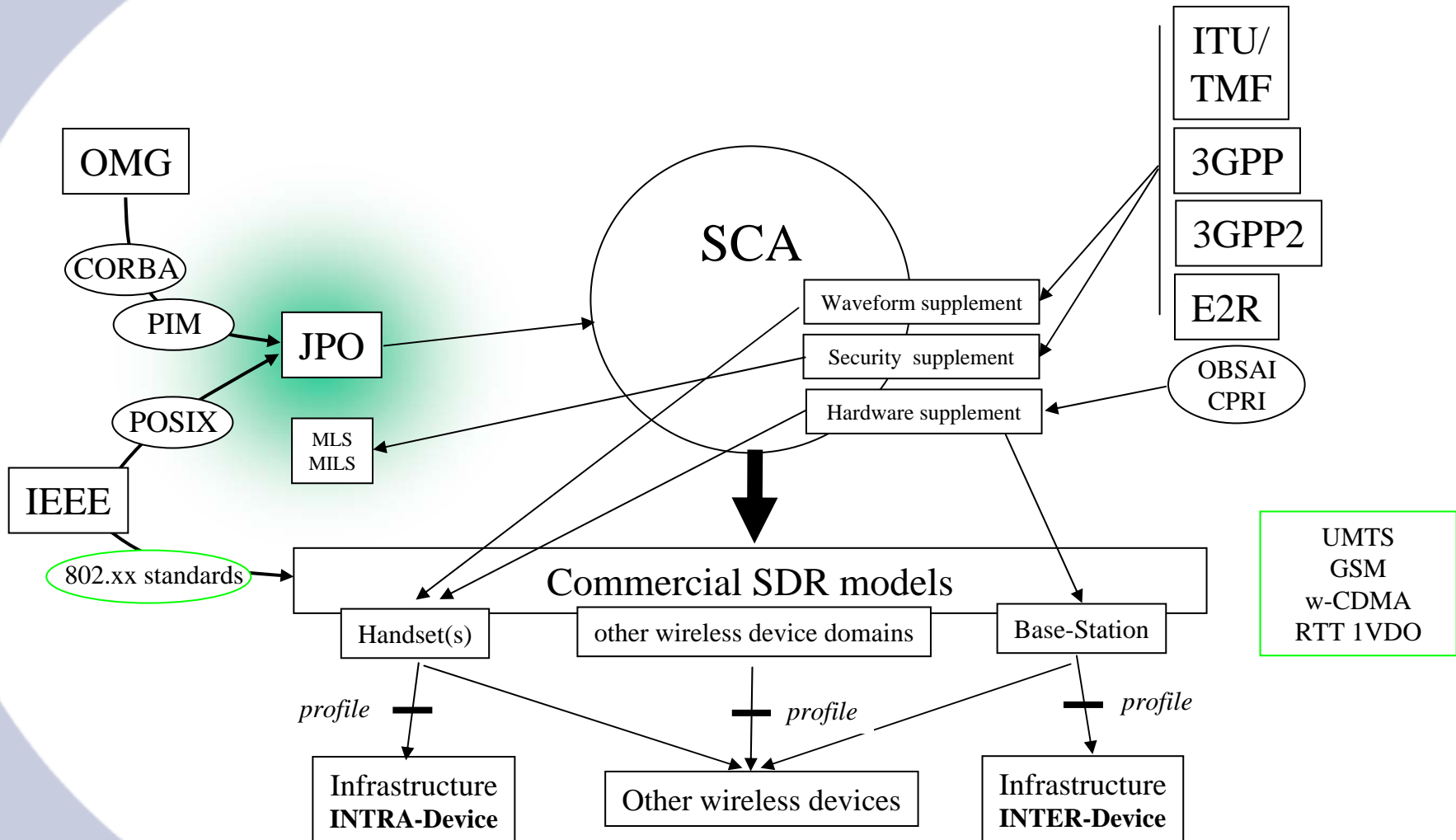
5. Contrasting with full SCA

▶ What would be the key additional elements in a commercial SBC mapped CoreFramework ?

- ▶ Synchronization
- ▶ Power regulation management
- ▶ Generic resource management
- ▶ Memory management
- ▶ Processor resource management
- ▶ Waveform specializations
- ▶ On-line upgrade/updates
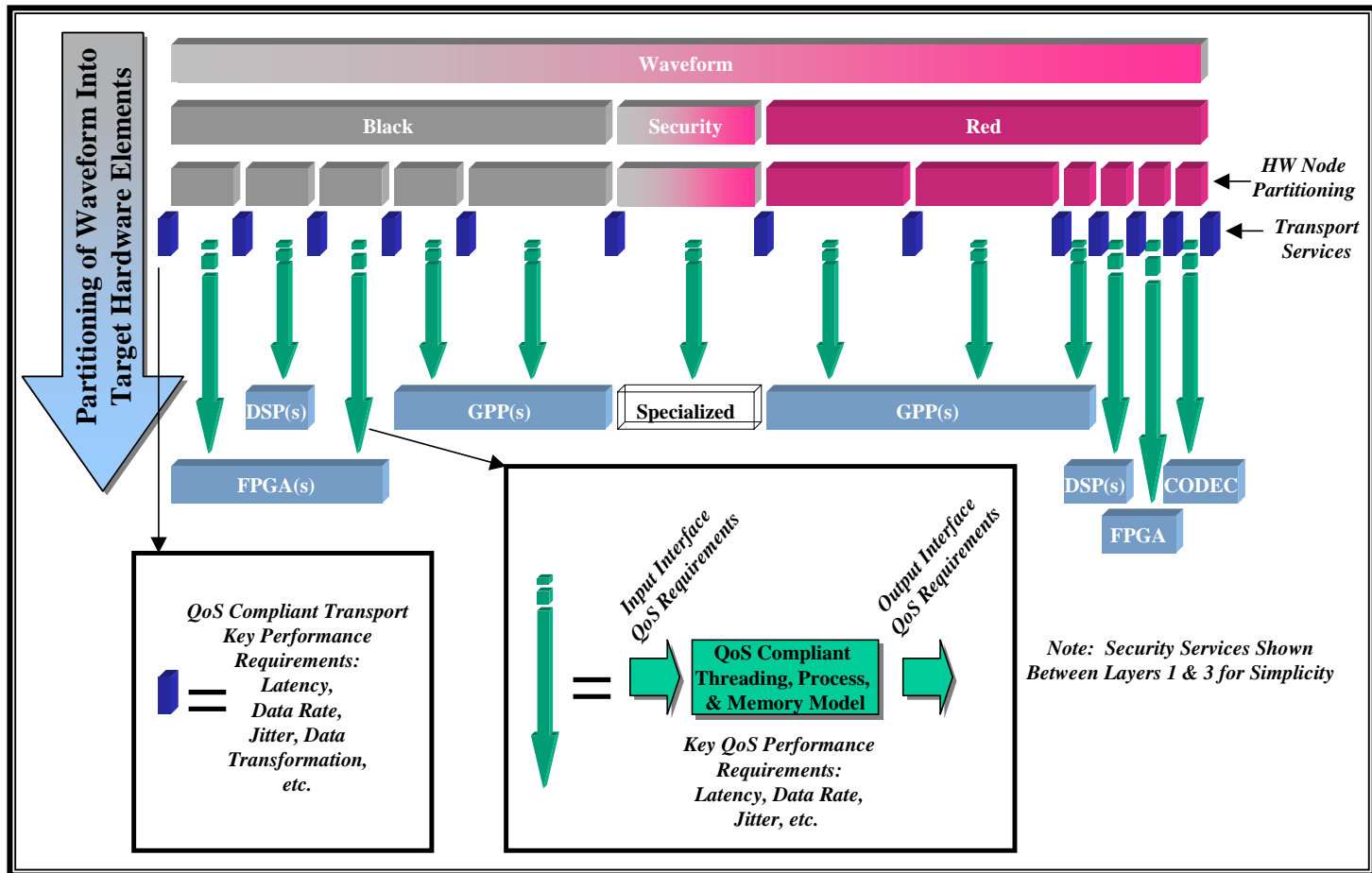- ▶ Vendor specializability plug-in framework

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From - Fette B., General Dynamics Recommendation to JPO on Hardware Supplement

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From - Fette B., LaMacchia M , Christensen E.,– *High Performance Software Radios, April 2004*.

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▶ Middleware for the soft-radio device – a more open device for supporting soft radio
  ▶ SDRF activities on Cognitive Radio, coupled with Hardware Layer abstraction models
  ▶ New efforts in 802.22 in CR also

▶ OMGs new RF-IF control in future – SBC 2004-08-15

▶ Control of RF FE and Adaptive beam forming and smart Antennas.

▶ Extensive work being done in the USA at Virginia Tech in the development of Smart Antennas, Antenna diversity, beam forming and more under Professor Jeff Reeds group. Group is also working extensively in active power management as part of an overall intelligent resource management strategy in the SDR device.

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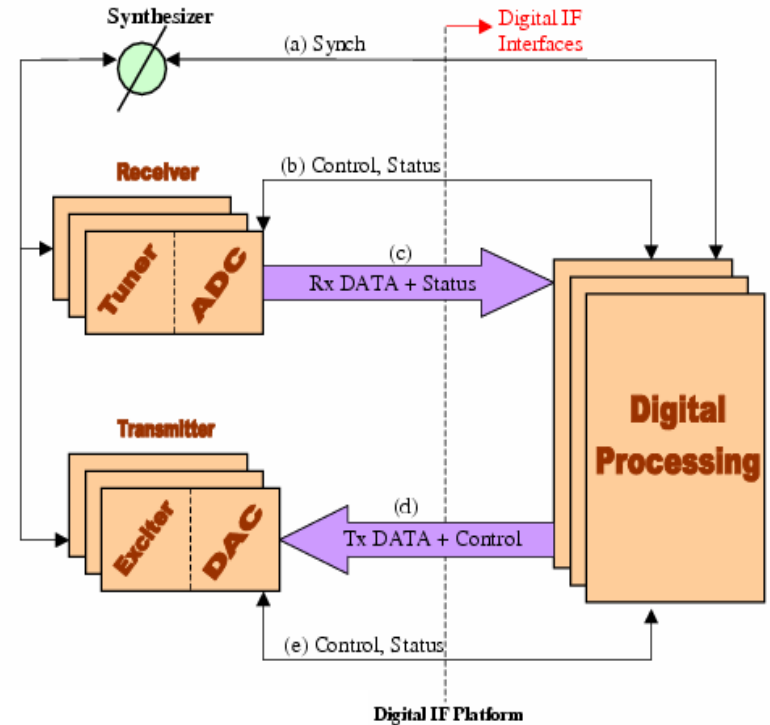
What might motivate a mapping of the SBC PIM to produce SDR platforms that can cater for a wide range of commercial waveform application media ?

Could such an SDR platform help me build more spectrally efficient devices ?

Or can this help promote spectrum sharing methods which are coming to the fore and the FCC is interested in looking into such solutions for policy making.

maybe this might be one way in…

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Models and specification for a SBC based CORE framework
- ❑ SBC PIM may be profiled and mapped appropriately
- ❑ Adoption and incorporation of new SBC specs like digital RF.

Composite and intuitive models for defining commonly used waveforms and standards
- ❑ CDMA, wCDMA, GSM over a UMTS infrastructure also SDR based

Commercial specifications to integrate base-station equipment via software OBSAI like specs coupled to the OMGs PIM-PSM model – BUT – profiled for different domains of the commercial sector – OMG already does this

An SBC architecture that takes from SCA and not necessarily CORBA which considers
- ❑ power
- ❑ cpu consumption
- ❑ smart antenna
- ❑ adaptive capability
- ❑ Software CF based control all the way to the front end – smart antennas and DRP technology.

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