Software Reconfigurable Radio

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Outline

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Software defined radio (SDR)

Definition by SDR Forum:-

- Software Defined Radio - elements of a wireless network whose operational modes and parameters can be changed or augmented, post-manufacturing, via software.

Definition by FCC (US):-

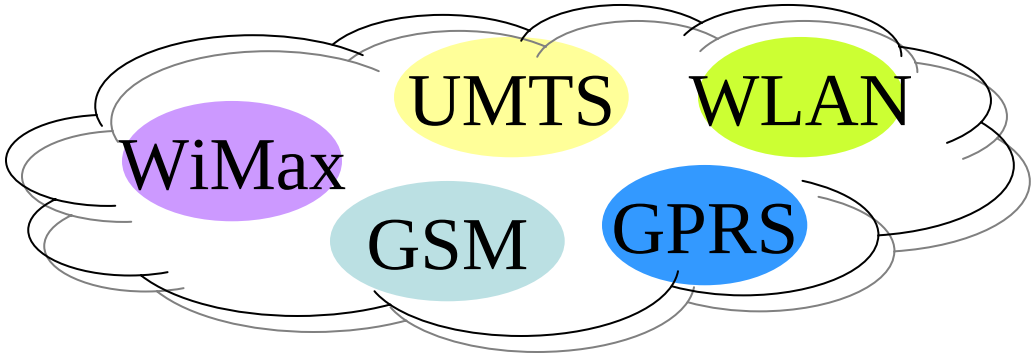
- A radio that includes a transmitter in which the operating parameters of frequency range, modulation type or maximum output power (either radiated or conducted) can be altered by making a change in software without making any changes to hardware components that affect the radio frequency emissions.

- So, what is software reconfigurable radio?

What is reconfigurable radio?

Definition by E^2R:-

- Evolution of Software defined radio (SDR).
- *Reconfigurability* provides essential mechanisms to terminals and network segments to adapt dynamically, transparently and securely to the most appropriate radio access technology.
  - via selecting pre-installed software components.
  - via software downloading and installation.



- Requires end-to-end reconfigurability (E^2R).

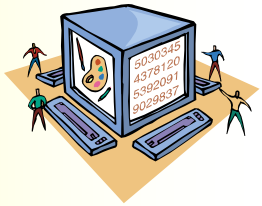
Why software reconfigurable radio?

- Rapid evolution of wireless communications system; 2G, 2.5G and 3G.
  - Equipment incompatibility.
  - Different link layer protocols.
  - Difficulties in the deployment of global roaming.
- B3G network aims to support integration and co-existence of multiple radio access technologies in a common composite radio environment.
- Concept of reconfigurability eases the implementation of the above environments.

Benefits

Manufacturer

Equipment manufacturers can use a common design for multi-functional radios leading to increased market size for a single product.



Operator

Network operators, the interoperability of different networks is enhanced and system upgrades and bugs fixing are easier to manage and implement.

Consumer

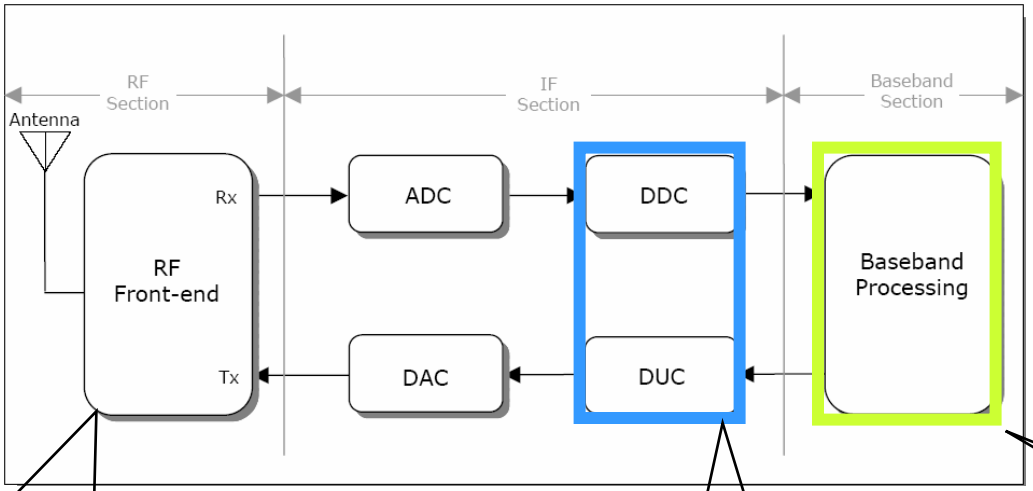
Subscribers benefit from the enhanced functionality of their SDR devices and the possibility to achieve ubiquitous connectivity.

Standards development organizations

- SDR Forum is involved in the development of specifications and standards for SDR
  - definitions
  - architecture
  - software
  - hardware
  - software download protocols,
  - security issues
  - etc..
- E^2R is a research project of the European Information Society Technologies (IST)
  - involved in defining standards and specifications particularly regarding the end-to-end reconfigurability of SDR.

SDR architecture

- Hardware architecture [1]



A generic digital transceiver

Programmable modules

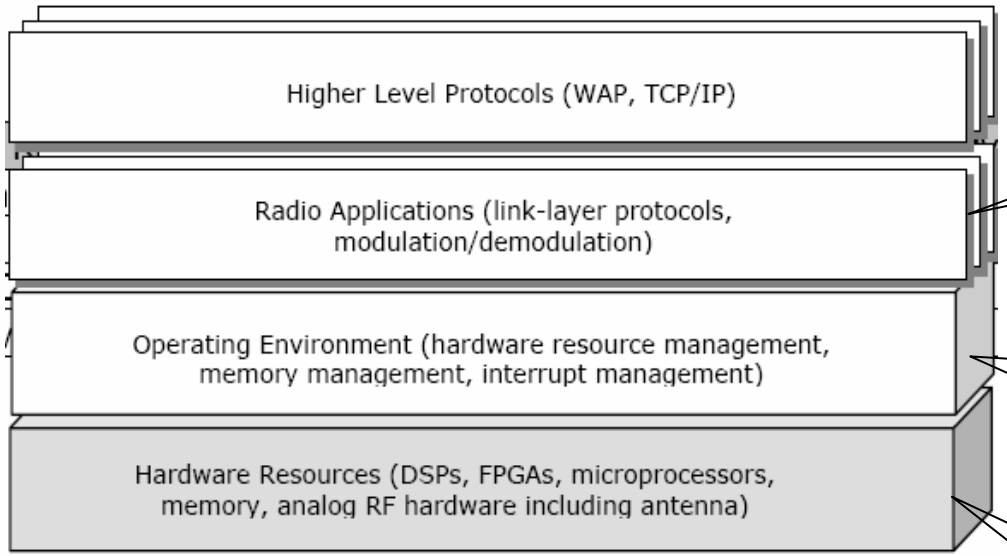
Implementation of programmable RF section is limited by the current ADC/DAC technologies - not sufficient in supporting the required digital bandwidth, dynamic range and sampling rate.

- Digital up-conversion
- Digital down-conversion

- Connection setup
- Equalization
- frequency hopping
- timing recovery
- correlation

SDR architecture

- Software architecture [1]



Typical software components in an SDR system

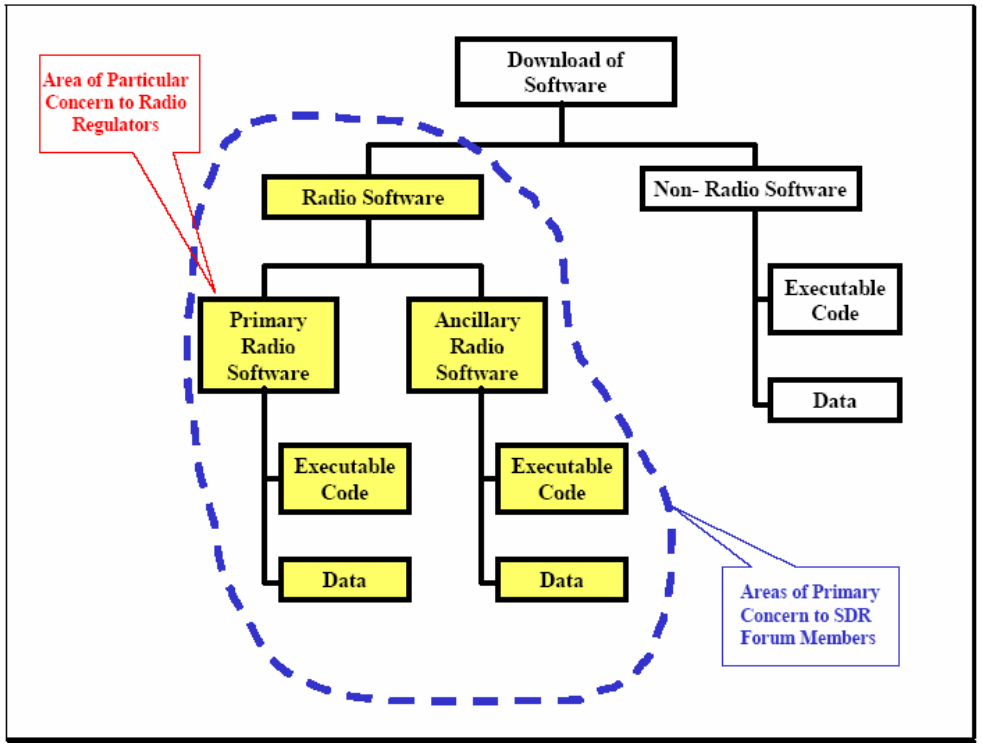
Provides link layer services to higher level protocols

Handles hardware resource management, memory and interrupt management.

Generic hardware platform built using programmable modules

Radio software download (1)

- Radio software download – process of delivering reconfiguration data and/or new executable code to an SDR device to modify its operation or performance [5] .



Characterizations of Software Download

Radio software download (2)

- Primary radio software
  - Directly affects the radio functionality.
  - Tightly coupled with the radio hardware.
- Ancillary radio software
  - Affects the usage of the device, e.g., IO driver and user interface.
- Executable codes
  - software for new DSP algorithms, bug fixing or new radio interface.
- Reconfiguration data
  - Parameters for modulation techniques, power level, operating frequency and etc..

Radio software download (3)

- Download initiation
  - By network
  - By user
  - By application

- Download environment includes
  - Local download
    - Via infrared, Bluetooth or cable interfaces
  - Remote download
    - Via radio interface from the supporting core radio network.

Software download scenario (1)

- Customization of common hardware platform
  - Operator A ordered terminals with air interface A.
  - New customer, operator B requests for terminals with air interface B.

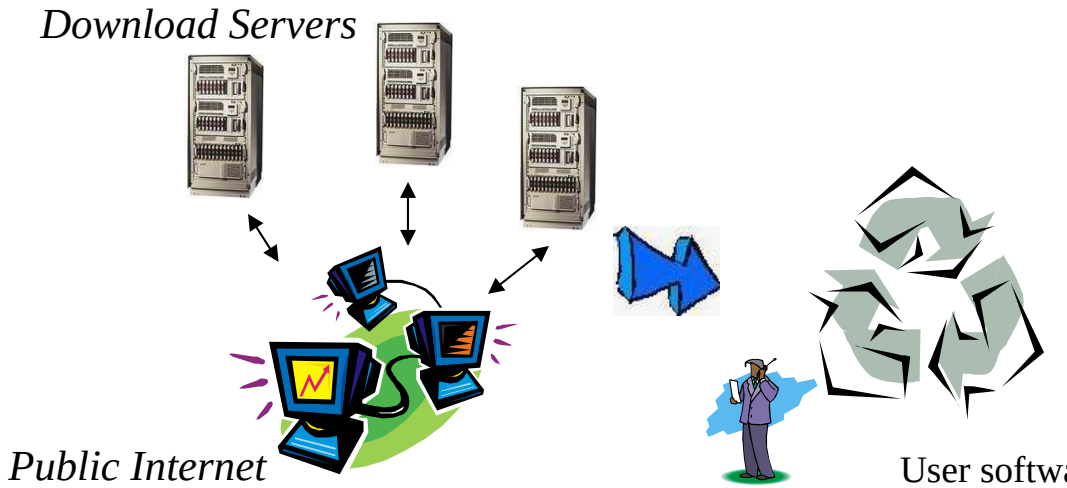
Product A Manufacturer Product B

Software Download [9]

  - Manufacturer downloads new SW (air interface B) to the same hardware platform and shipping to operator B.

Software download scenario (2)

- Ubiquitous access
  - User plans to travel to a country operating cellular networks that are incompatible to the user's home country.
  - User connects to internet and downloads the necessary radio interfaces via cable or wireless interfaces.
  - Upon arrival at destination, user activate the new wireless interfaces and access the services as usual.



User software download [9]

End-to-end reconfigurability (1)

Capabilities of end-to-end reconfigurable devices [2]:-

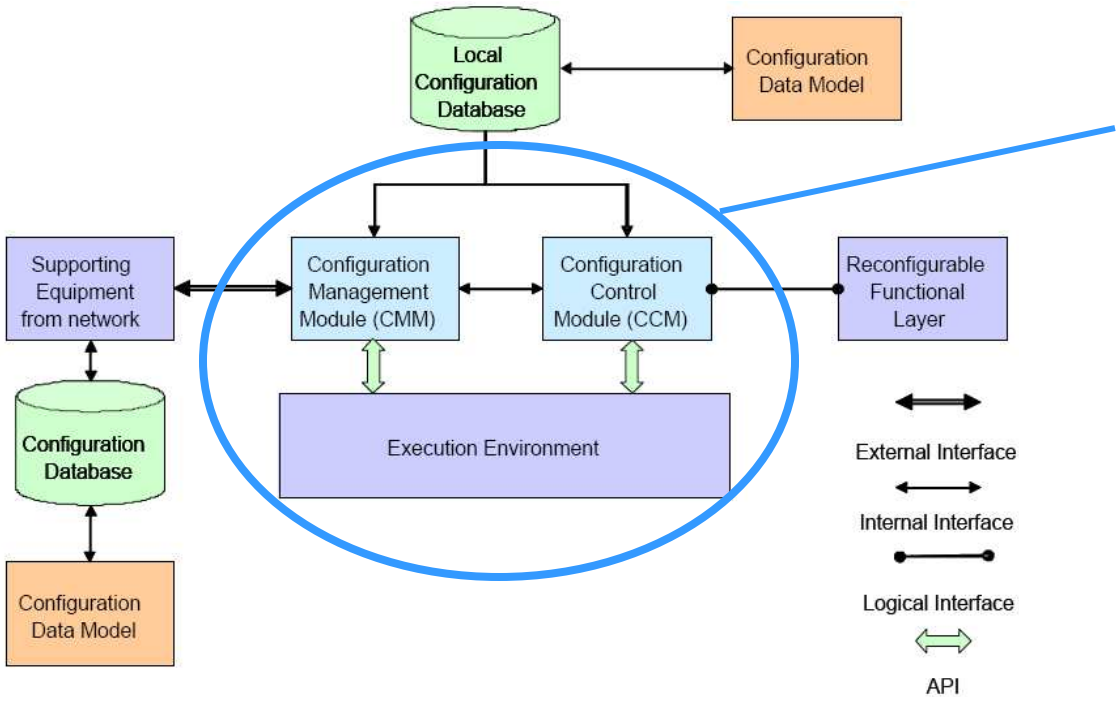
- Monitoring and discovering available access networks
  - Periodically check for possible new RAT in the service area offering better opportunities such as higher QoS, lower cost per QoS level and service.
- Negotiating
  - Negotiate offers with the available networks and selecting the most appropriate RAT.
- Providing support
  - Support various protocols and protocol features.
  - Capable of dynamic insertion, replacement and configuration of protocols components from different vendors.

End-to-end reconfigurability (2)

- Verifying
  - Verify the secure level of a download source prior to downloading and installation of software downloads (authenticity, authorization and integrity check).
- Controlling and coordinating
  - Control and coordinate the reconfiguration of various equipment components.
- Interacting
  - Interact with external entities such as network entities.

E²R management and control architecture (1)

- The requirements for the E²R equipment needs a generic management and control architecture.

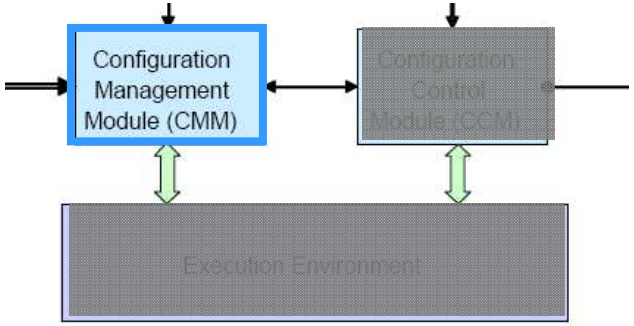


Comprises of 3 main components:-

- CMM
- CCM
- ExEn

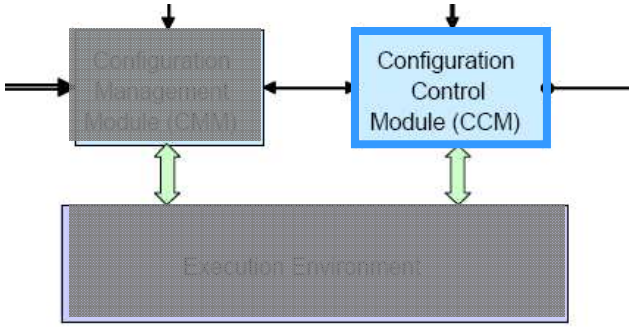
High-level structure of equipment management and control architecture [2].

Configuration management module (CMM)



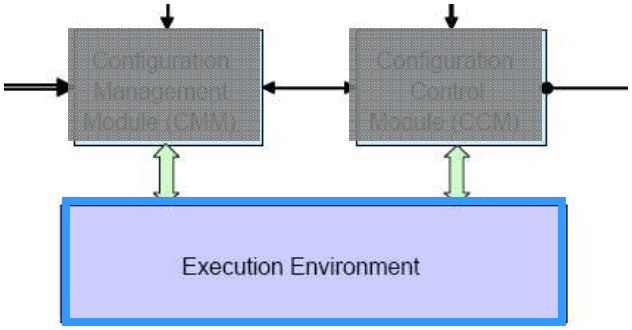
- CMM is a functional entity within the reconfigurable equipment.
  - Responsible for the management of all configuration tasks
  - Negotiation of reconfiguration decisions with other entities.
  - Manages the distributed controllers that performs the reconfiguration functions (in the CCM).
  - Ensuring security.

Configuration control module (CCM)



- CCM is a supporting entity.
  - Control and supervision of reconfiguration execution.
    - Done using specific commands /triggers and functions of a given layer or execution environment.
  - Initiate, coordinate and perform reconfiguration functions.
    - Monitoring and discovery, software download, model selection and switching.

Execution environment (ExEn)



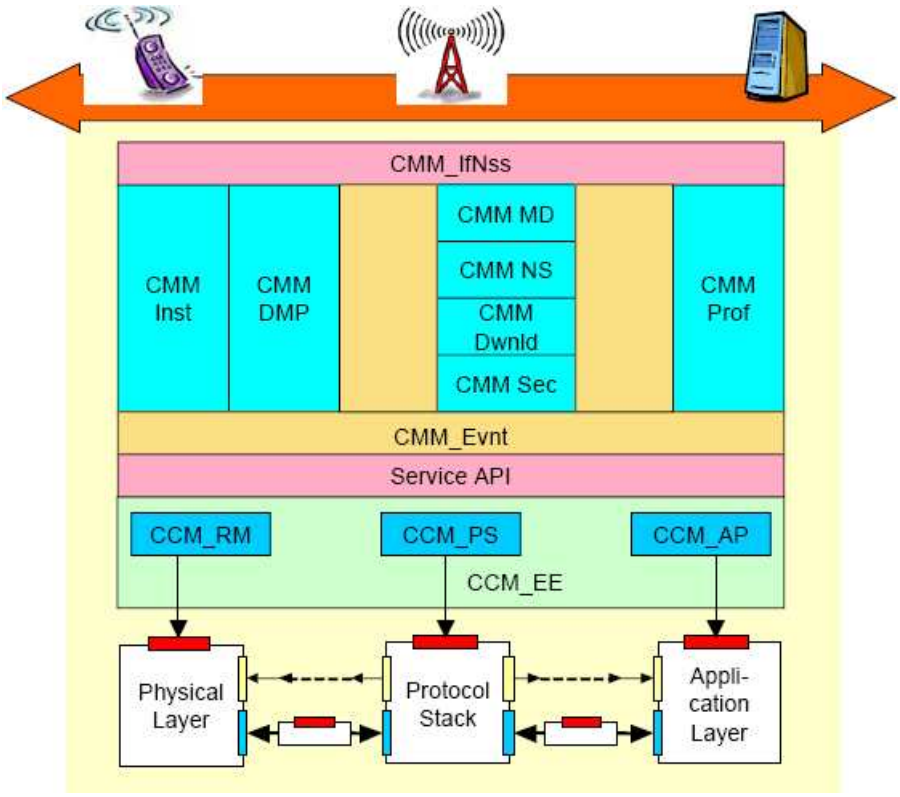
- ExEn is a platform for executing all equipment functions including configuration management and control.
  - Provides the CMM and CCM with consistent interface for configuration actions.
  - Provides basic mechanisms required for dynamic, reliable and secure change of equipment operation.

Breakdown of CMM and CCM functional entities

Abbreviations

- CMM_Prof – Profiles
- CMM_MD – Monitoring and Discovery
- CMM_NS – Negotiation and Selection
- CMM_Dwnld – Downloads
- CMM_Sec – Security
- CMM_DMP – Decision-making and Policy enforcement
- CMM_Inst – Installation
- CMM_IfNss – Interface with Network Support Services
- CMM_Evnt – Event Handler

- CCM_AP – Application Layer
- CCM_PS – Protocol Stack
- CCM_RM – Reconfigurable Modem
- CCM_EE – Execution Environment

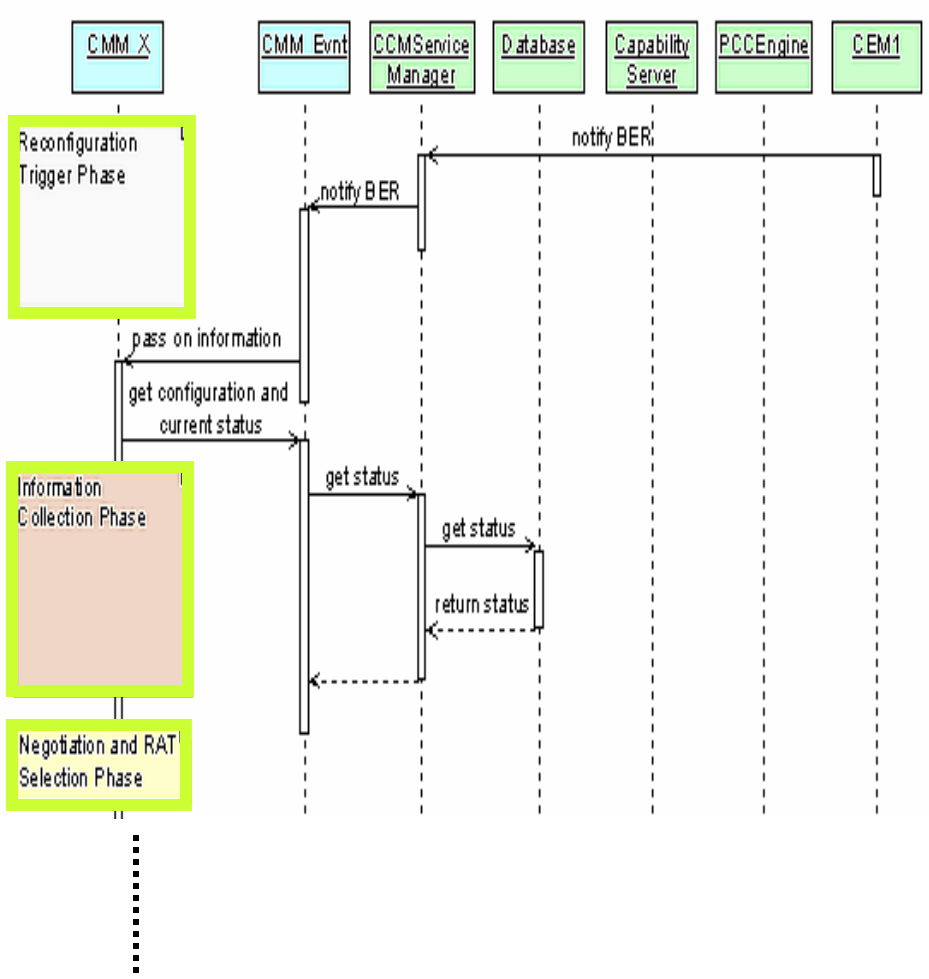


Functional entities of CMM and CCM [2]

Deployment of reconfiguration

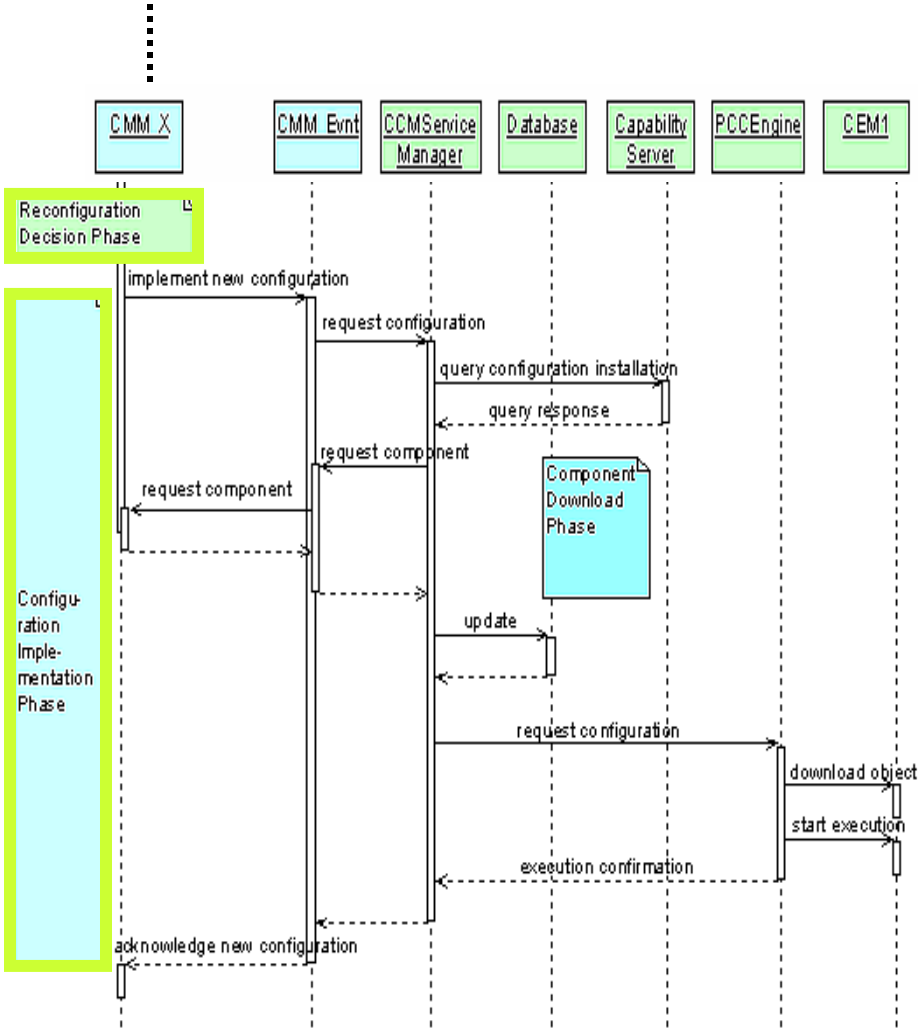
- The deployment of reconfiguration of an equipment involves interaction between the CMM and CCM. Following are the typical phases.
  - Reconfiguration trigger phase
  - Information collection phase
  - Negotiation and RAT selection phase
  - Reconfiguration decision phase
  - Configuration implementation phase

CCM and CMM interactions (1)



- Reconfiguration trigger phase
  - CCM reports status change to CMM_Evnt
  - CMM_Evnt sends the message to the CMM_MD
  - CMM_MD decides whether or not to trigger the reconfiguration process.
- Information collection phase
  - CMM retrieves information from the CCMs.
- Negotiation and RAT selection phase
  - The CMM_NS negotiates and select the suitable RAT based on current status and capabilities and passes to CMM_DMP.
  - The CMM_DMP triggers the decision phase.

CCM and CMM interactions (2)



- Reconfiguration decision phase
  - CMM_DMP decides new configuration implementation based on current status and reconfiguration policy rules.
  - CMM_DMP instructs CMM_Inst to implement the configuration.
- Configuration implementation phase
  - CMM_Inst instructs CCM_RM to implement new configuration.
  - CCM Service Manager checks if the configuration can be supported. Software download might be needed.
  - CCM Service Manager request CMM for component download to Database.
  - Upon download completion, request is sent to PCC engine.
  - PCC engine downloads new object to CEM and executes the configuration.

Conclusions

- Software reconfigurable radio is a developing technology that involves studies of many aspects extending from user equipment to system level considerations.
- The reconfigurability concept is developed to support rollout of B3G and integration of different RATs.
- E^2R devices need to have advance functionalities to support the end-to-end reconfigurability for dynamic adaptation to the best network in a multi-RATs environment.
- Management and control architecture is needed to support this functionalities.

References

1. Wipro technologies, “Software-defined radio, A technology overview,” white paper, August 2002.
2. J. Vogler, G. Pfeiffer, V. Stavroulaki, P. Demestichas, A. Katidiotis, D. Petromanolakis, N. Alonistioti, E. Patouni et. al., “Equipment management and control architecture,” *End-to-End Reconfigurability* (*E2R*) *white paper*, July 2005.
3. IST-2003-507995 E2R Project, http://www.er2.motlabs.com
4. Software Defined Radio Forum website, www.sdrforum.org.
5. SDR Forum, “Overview and definition of software download for RF reconfiguration,” SDRF-02-A-0002-V0.00, August 2002.
6. E2R, “End-to-end reconfigurability system requirements,” *End-to-End Reconfigurability* (*E2R*) *white paper*, January 2006.
7. E2R, “End-to-end reconfigurability system architecture,” *End-to-End Reconfigurability* (*E2R*) *white paper*, January 2006.
8. E2R white papers repository, http://e2r.motlabs.com/whitepapers/
9. http://www.sdrforum.org/MTGS/mtg_21_nov00/sdr_scenarios_motorola_01_03_01.ppt.

Homework

1. Briefly describe the concept of reconfigurability.

2. Explain and give example(s) how the concept of reconfigurability is able to support/smoothen the rollout of B3G network.