

IMPLEMENTATION OF WiBro SMART ANTENNA BASE STATION SYSTEM WITH OPEN ARCHITECTURE FOR SDR FUNCTIONALITY

Taeyoul Oh, Seungheon Hyeon*, Namkyu Ryu*, Yusuk Yun*,
Seungwon Choi*, and Jinsung Choi***

** HY-SDR Research Center, School of Electrical and Computer Engineering, Hanyang University, Seoul, Korea*

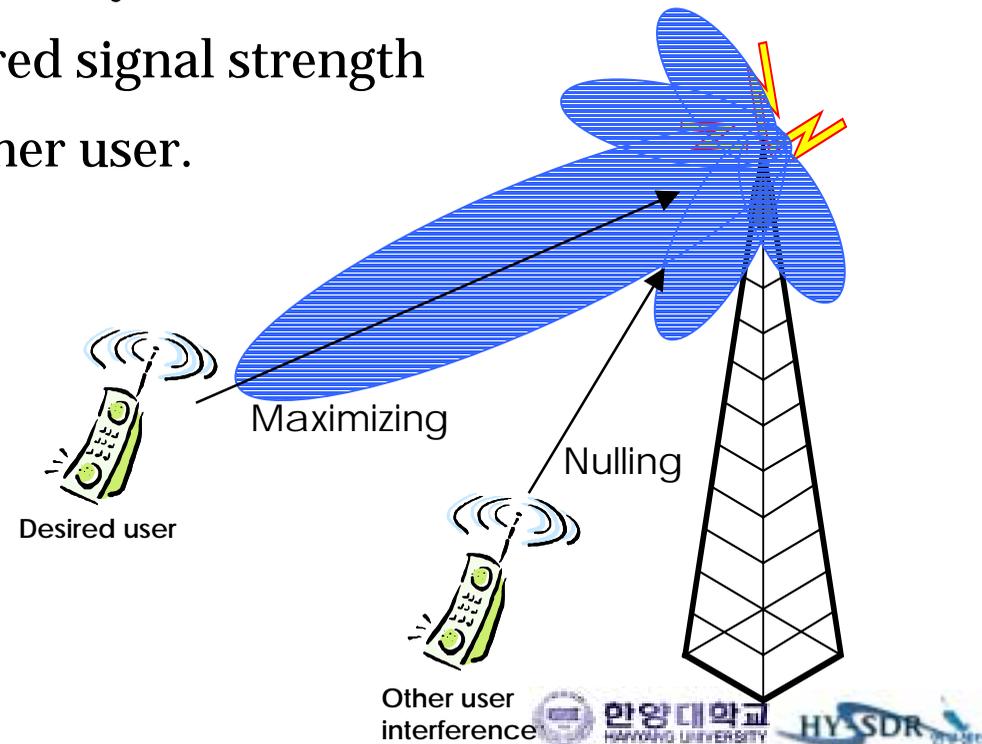
*** Mobile Communication Tech Research Lab., CTO, LG Electronics, Anyang-shi, Kyonggi-do, Korea*

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2. SMART ANTENNA OPEN ARCHITECTURE
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I. INTRODUCTION

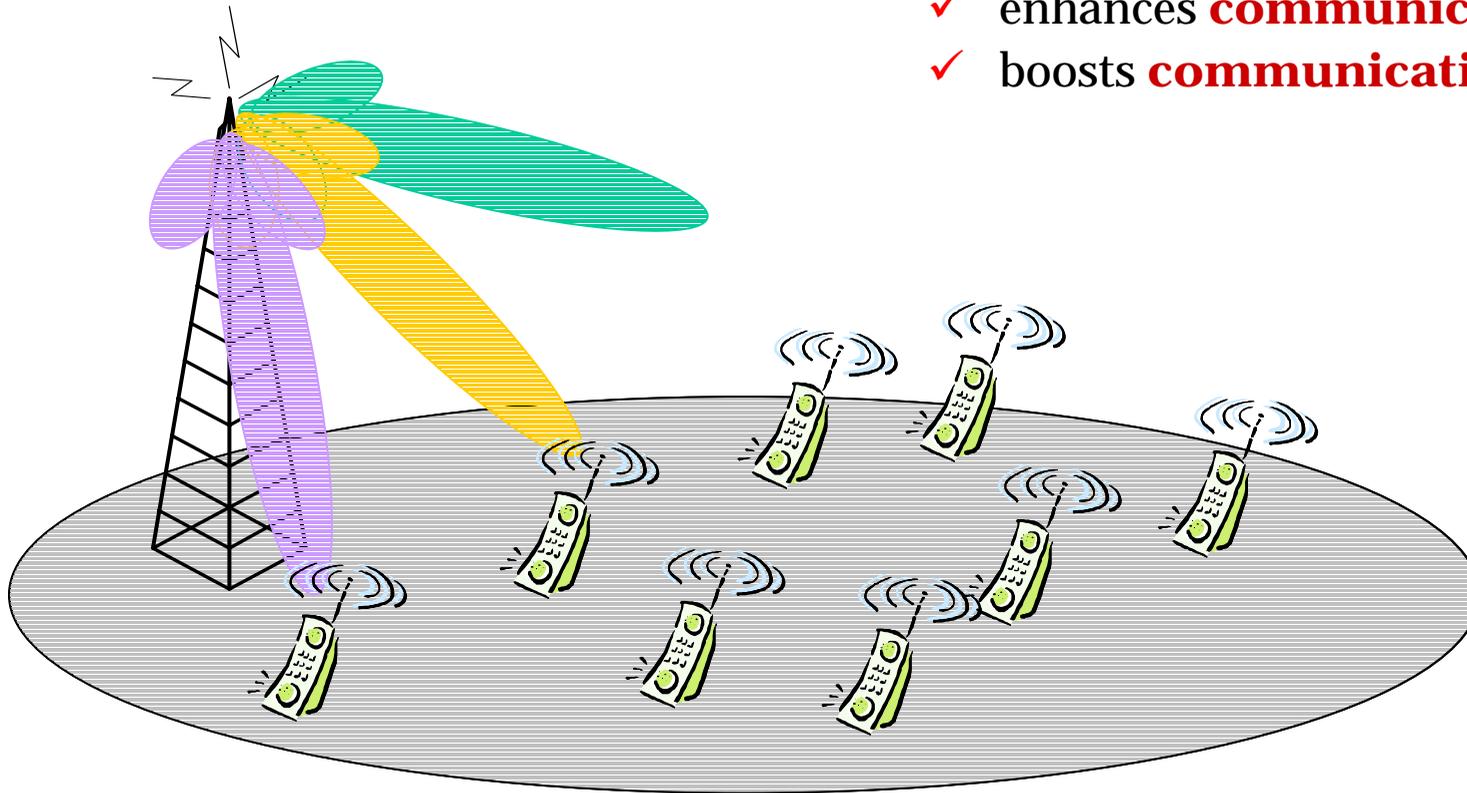
- What is Smart Antenna (SA) ?
 - SA should be equipped with antenna array.
 - Signals are collected by individual elements.
 - The signals are weighted and coherently combined.
 - The weight vector maximizes desired signal strength
 - and reduces interferences from other user.



I. INTRODUCTION (cont'd)

• Advantage of Smart Antenna (SA)

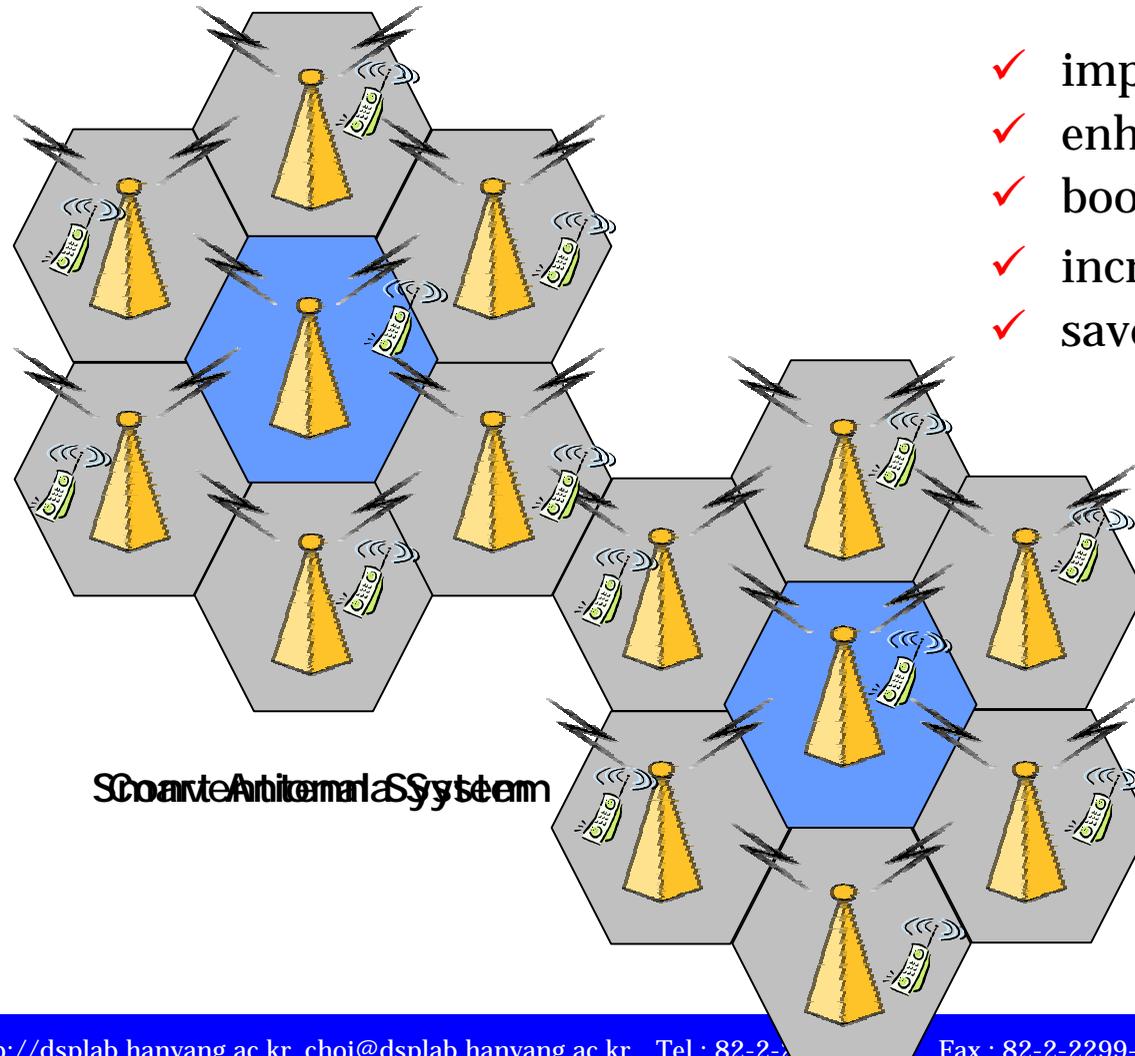
Smart Antenna System



- ✓ improves **communication capacity**
- ✓ enhances **communication quality**
- ✓ boosts **communication throughput**

I. INTRODUCTION (cont'd)

• Advantage of Smart Antenna (SA)



- ✓ improves **communication capacity**
- ✓ enhances **communication quality**
- ✓ boosts **communication throughput**
- ✓ increases **cell coverage**
- ✓ saves MS **battery life time**

I. INTRODUCTION (cont'd)

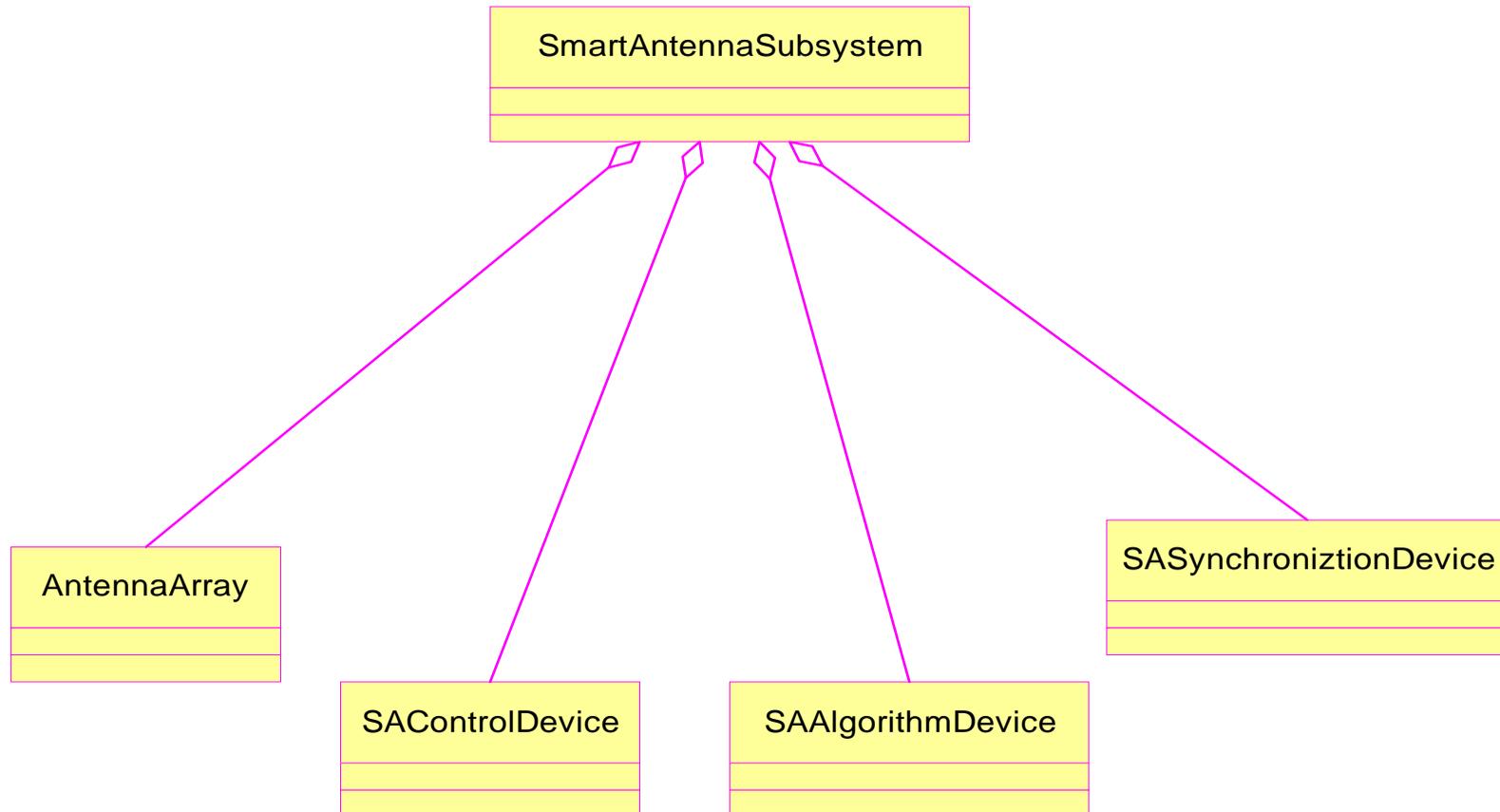
- Concept of SDR (software defined radio)
 - All functionalities of radio communication system can be reconfigured by software.
 - The radio systems are interoperable.
 - To the interoperability, components of radio communication system are to be portable, inter-changeable, and reusable.
 - Additionally, the architecture of radio communication system is to be open, common, distributed, embeddable, object-oriented, and language/platform independent.

I. INTRODUCTION (cont'd)

- The SDR technology can offer
 - flexibility to handle a variety of multimedia services and standards,
 - cost efficiency to upgrade or change system functionality,
 - facility to develop radio communication system in a unified environment.

II. SMART ANTENNA OPEN ARCHITECTURE

- Components Breakdown



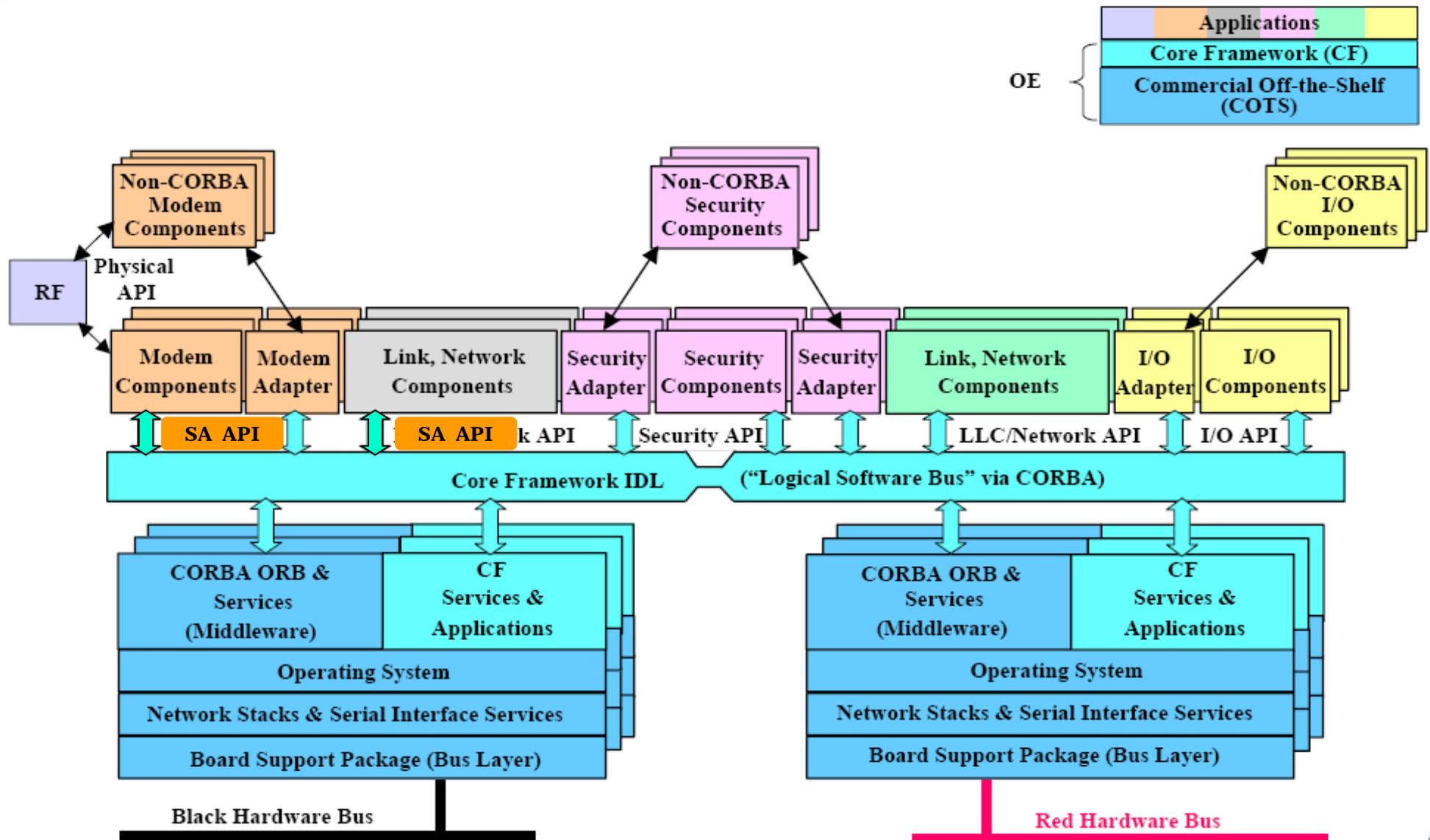
*Source : "Use Cases for creation of Smart Antenna APIs" OMG sbc/2005-05-01, Sep 2005, p6



한양대학교
HANYANG UNIVERSITY



II. SMART ANTENNA OPEN ARCHITECTURE (cont'd)



*Source : SDRF Technical Report ver 2.1, Nov 1999, p5-44

II. SMART ANTENNA OPEN ARCHITECTURE (cont'd)

- Requirement for Open Architecture
 - Antenna
 - Broadband, Multi-band/Tunable antenna
 - RF/IF
 - Direct RF sampling, High linear properties
 - AD/DA
 - High speed, high resolution
 - Base-band Signal Processing
 - High capacity, parallel processing, flexibility, reconfigurability
 - Software Architecture
 - Language/platform independent, object-oriented, APIs for hardware abstraction

III. SMART ANTENNA APIs

- ✓ **Commands:** Asynchronous protocols to SABS primitives for performing immediate and non-persistent actions.
- ✓ **Variables:** Persistent SABS state or long-term measurement primitives.
- ✓ **Response:** Synchronous response to command or variable operation.
- ✓ **Signals:** Asynchronous protocols to SDR Network primitives for reporting recent and non-persistent events.

III. SMART ANTENNA APIs (cont'd)

◆ Commands

Commands	Requirements	Qualifiers	Description	Response
•CmdBeamformerReset	Mandatory		•Beamformer Soft Reset	•Beamformer Soft Reset OK. •Beamformer Soft Reset Failure.
•CmdBeamFormerExec	Mandatory		•Beamformer Execution on/off	•Beamformer Execution OK. •Beamformer Execution Failure.
•CmdCalibrationExec	Mandatory		•Calibration Execution on/off	•Calibration Execution OK. •Calibration Execution Failure.
•CmdBeamFormerDMExec	Optional		•Beamformer Diagnostic monitoring on/off	•Beamformer Diagnostic monitoring OK. •Beamformer Diagnostic monitoring Failure.

◆ Signals

Signals	Requirements	Qualifiers	Description
•SignBeamformer	Mandatory		•Beamformer Module loaded
•SigBeamformerError	Mandatory	•Interrupt	•Indicating the Beamformer Error

III. SMART ANTENNA APIs (cont'd)

◆ Variables

Variables	Requirements	Qualifiers	Description
•VarMode	Mandatory	Info	•Returns set of available system modes
		Set	•Set system mode (Array, Diversity, Single Ant. etc)
		Get	•Get current system mode
•VarAlgorithm	Mandatory	Info	•Returns set of available algorithms (Response)
		Set	•Set algorithm type (MMSE, Eigen-based, RLS, etc)
		Get	•Get current algorithm type
•VarBeamDirection	Optional	Info	•Returns set of available beam directions (For tracking of particular users)
		Set	•Set direction of beam (TX,RX)
		Get	•Get direction of beam (TX,RX)
•VarCalibrationMode	Optional	Info	•Returns set of available Calibration Modes
		Set	•Set Calibration Mode
		Get	•Get current Calibration Mode
•VarCalibration	optional	Get	•Get current calibration value (TX,RX)

III. SMART ANTENNA APIs (cont'd)

◆ Variables

Variables	Requirements	Qualifiers	Description
•VarLevelofCalibration	Mandatory	Info	Returns level of calibration required for each application
		Set	Set level of calibration
•VarAntType	Mandatory	Info	Returns the various antenna topologies available for eg. Circular array , planar array for the SA to be configured
		Set	Set antenna type
		Get	Get current antenna type
•VarRadiationPattern	Mandatory	Info	Returns max RadiationPattern, minRadiation Pattern
		Set	Set radiation pattern for antenna array as well as for single antenna
		Get	Get radiation pattern
•VarNoofElements	Optional Can be used in case of antenna array system	Info	Returns the number of antenna elements
		Set	Set number of radiating antenna elements
		Get	Get number of radiating elements

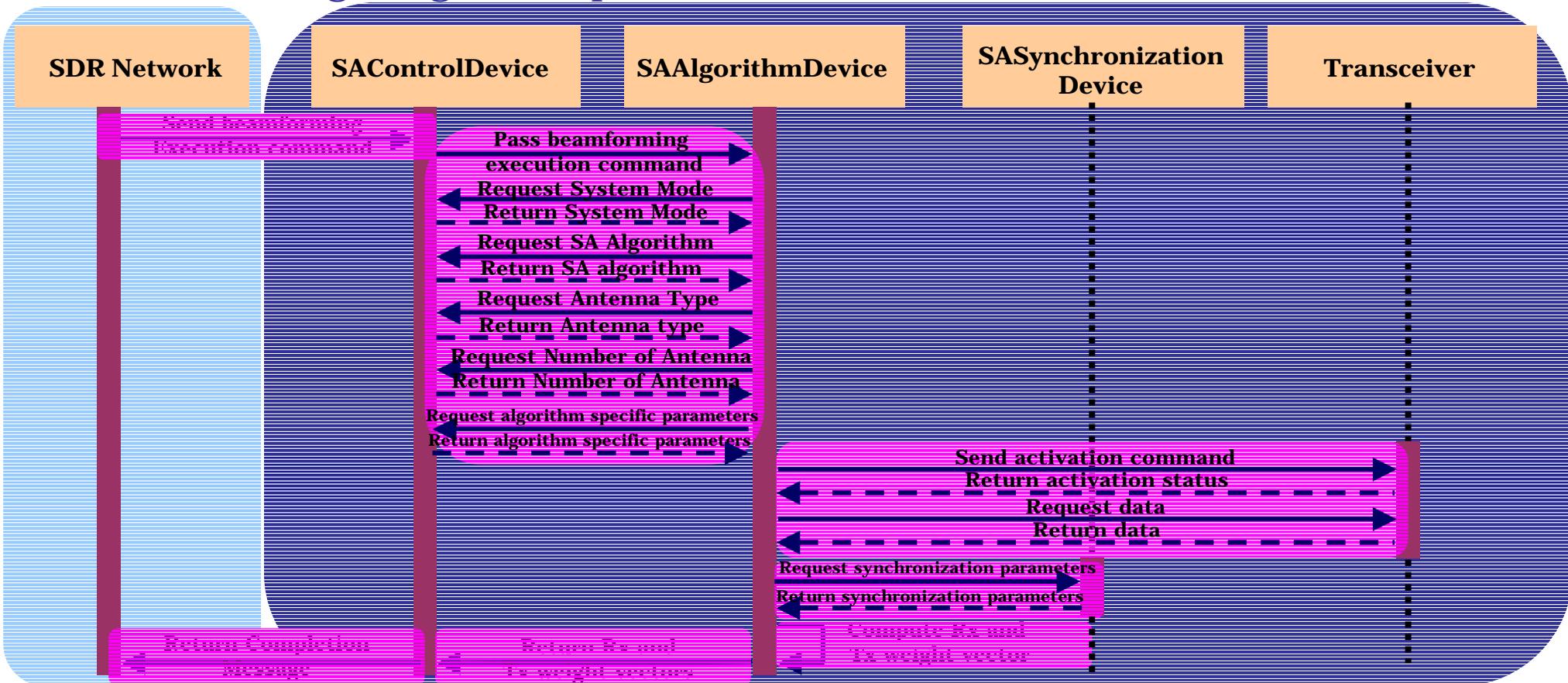
III. SMART ANTENNA APIs (cont'd)

◆ Variables

Variables	Requirements	Qualifiers	Description
•VarAuxPilotWalsh	Mandatory	Info	•Returns Ability of Auxiliary Pilot Decoding
		Set	•Set Auxiliary Pilot Walsh (Walsh Num, Walsh length, QOF)
		Get	•Get current Auxiliary Pilot Walsh (Walsh Num, Walsh length, QOF)
•VarAuxPilotRelativeGain	Mandatory	Info	•Returns Ability of Auxiliary Pilot Decoding
		Set	•Set Auxiliary Pilot Relative Gain
		Get	•Get current Auxiliary Pilot Relative Gain
•VarSmartAntennaHPAPower	Mandatory	Info	•Returns Available Output Power Range of HPA Linear Operation (dBm, Watts)
		Set	•Set HPA Output Power
		Get	•Get Current HPA Output Power
•VarRevPowerConStepGain	Mandatory	Info	•Returns Enable or Disable of Reverse Power Control
		Set	•Set Reverse Power Control Step Gain (dB)
		Get	•Set Current Reverse Power Control Step Gain (dB)
•VarFowPowerConStepGain	Mandatory	Info	•Returns Enable or Disable of Forward Power Control
		Set	•Set Forward Power Control Step Gain (dB)
		Get	•Get Current Forward Power Control Step Gain (dB)

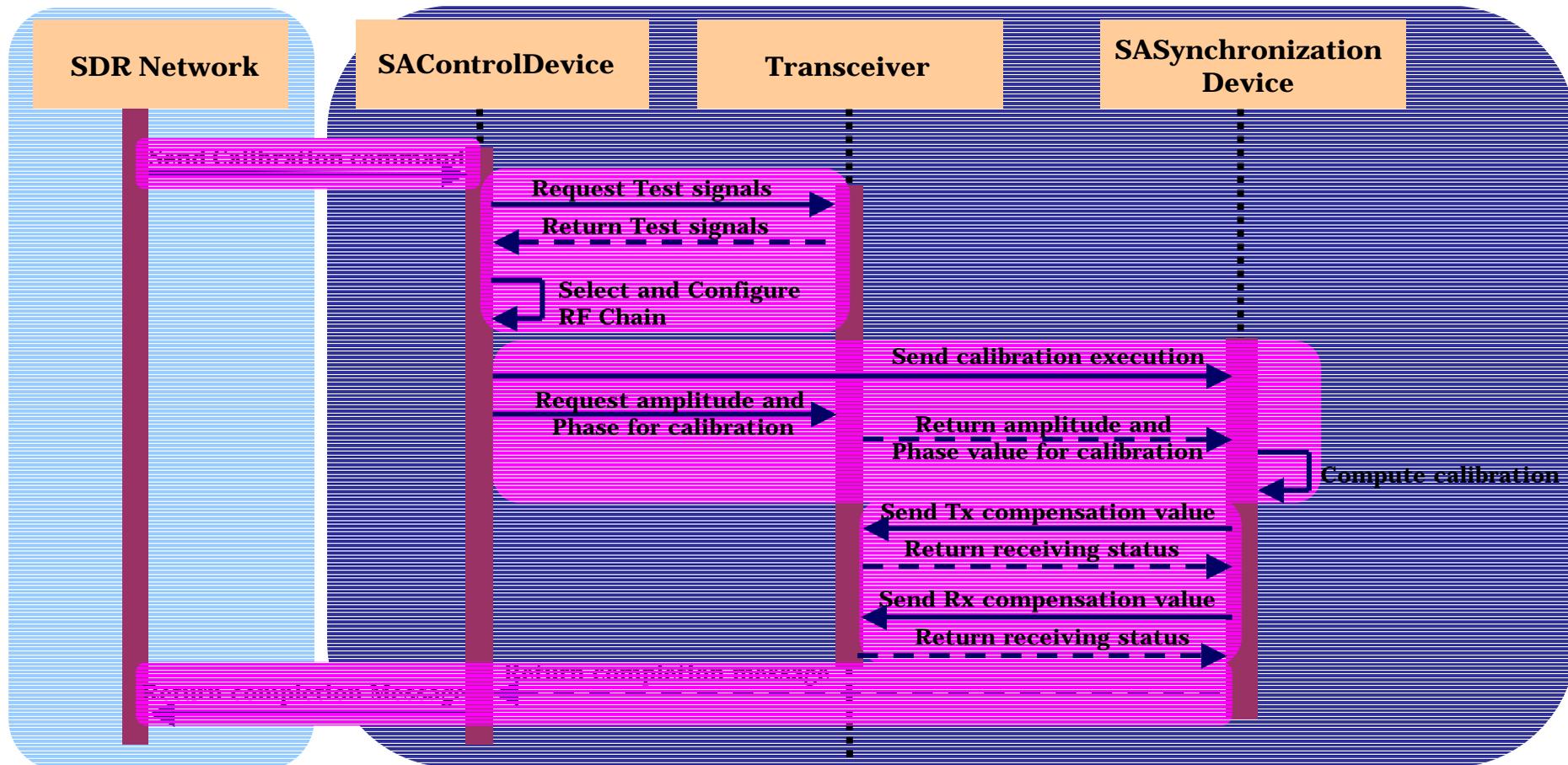
III. SMART ANTENNA APIs (cont'd)

- Beamforming weight computation



III. SMART ANTENNA APIs (cont'd)

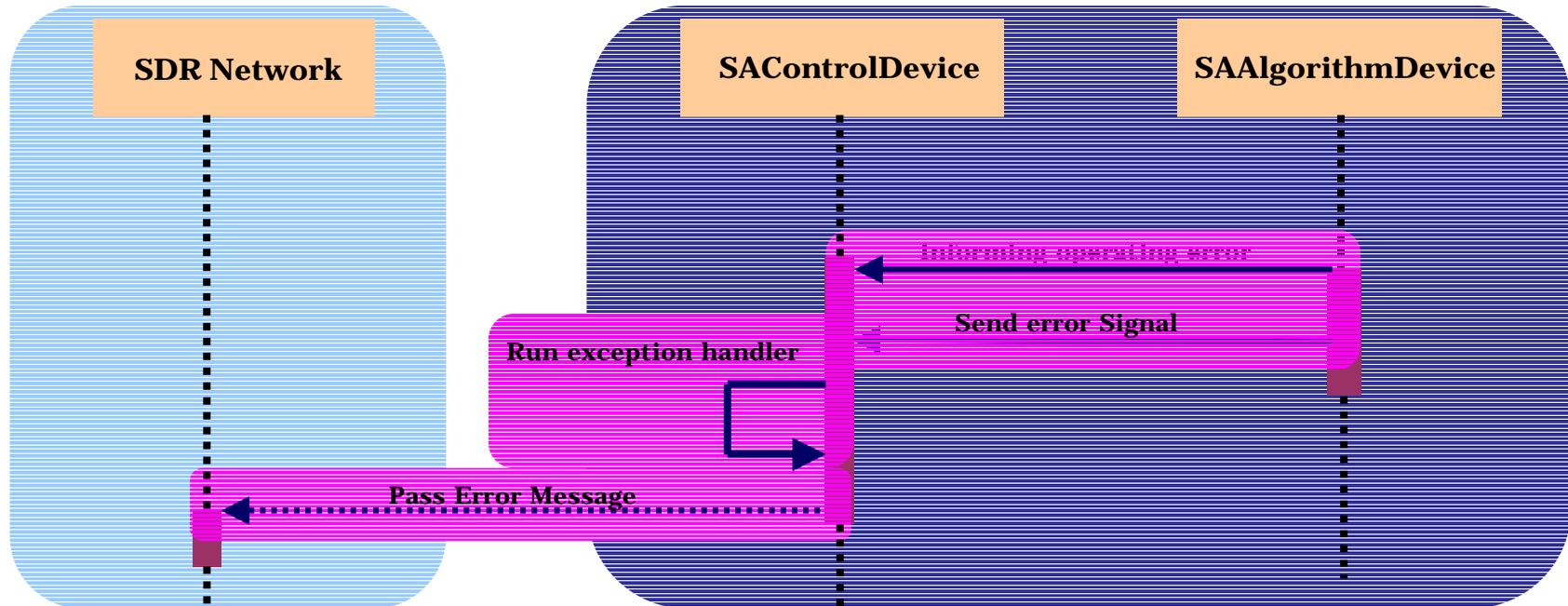
- Calibration execution command



III. SMART ANTENNA APIs (cont'd)

- Beamformer module error

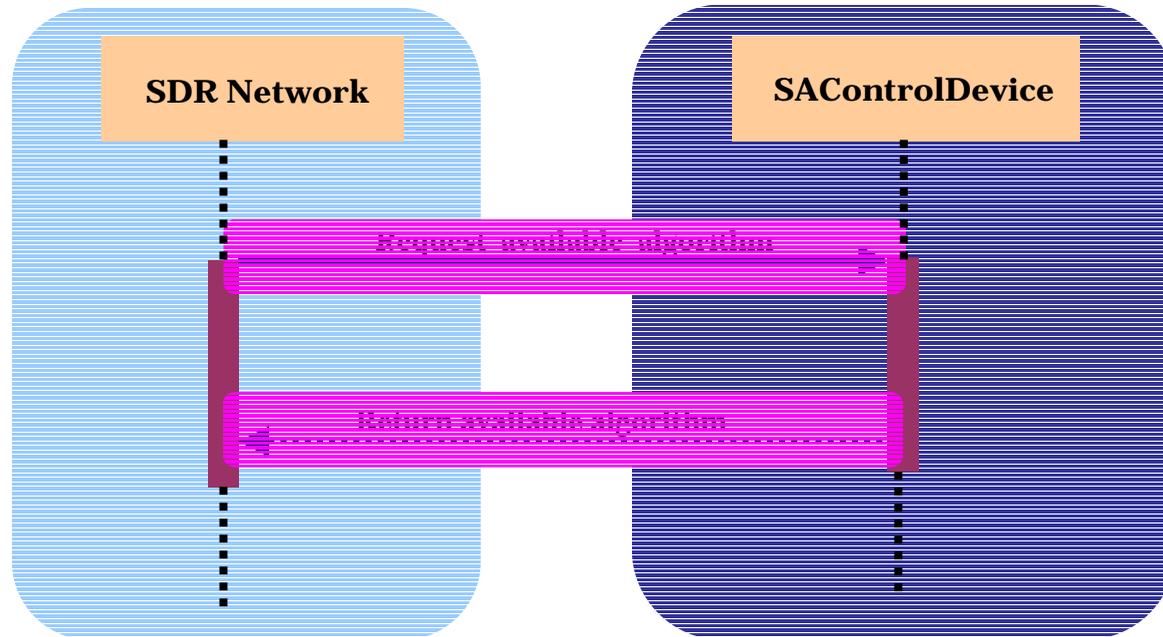
Signal



III. SMART ANTENNA APIs (cont'd)

- Algorithm Information

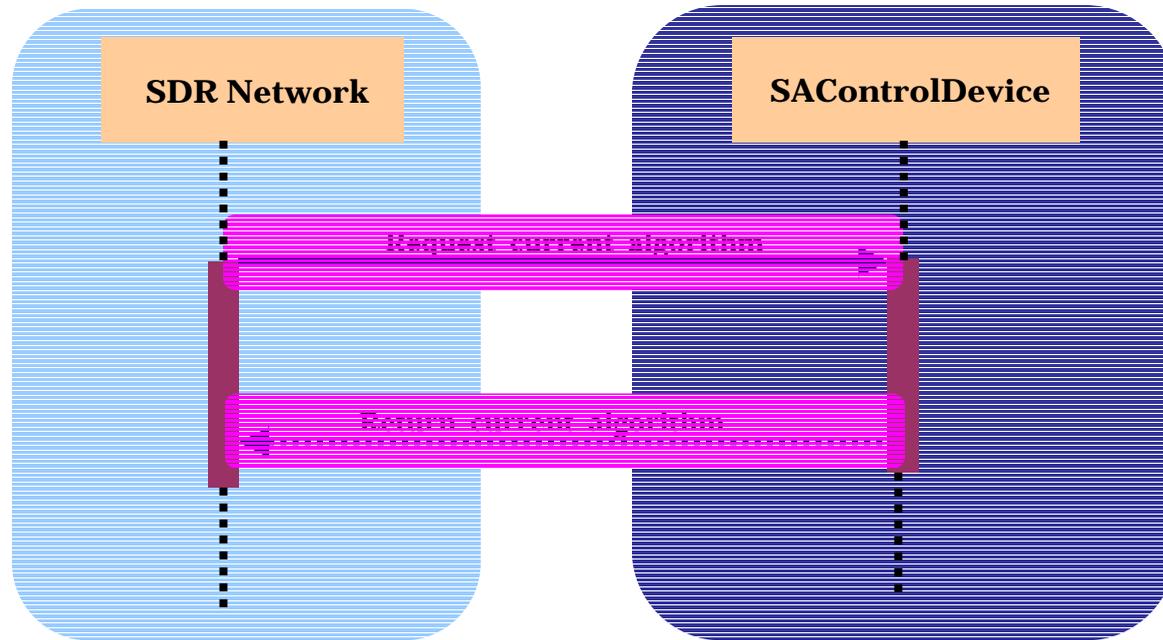
Variable



III. SMART ANTENNA APIs (cont'd)

- Algorithm Get

Variable

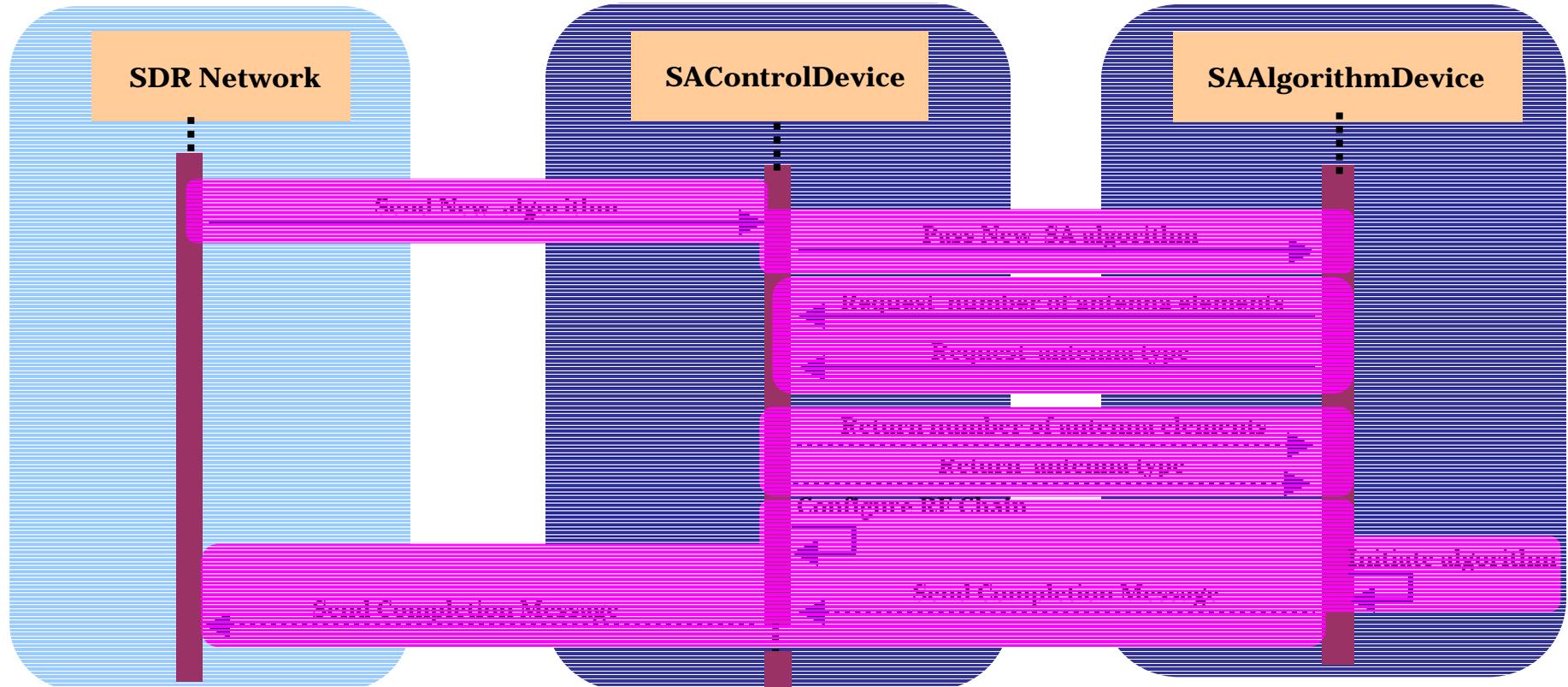


◆◆ The SDR Network Device requests the current SA algorithm to the SAControlDevice

III. SMART ANTENNA APIs (cont'd)

- Algorithm Set

Variable



IV. IMPLEMENTATION OF SDR-based WiBro RAS

● Specification

□ Supported standard:

IEEE802.16d(2004, Cor1_D4), IEEE802.16e_D12

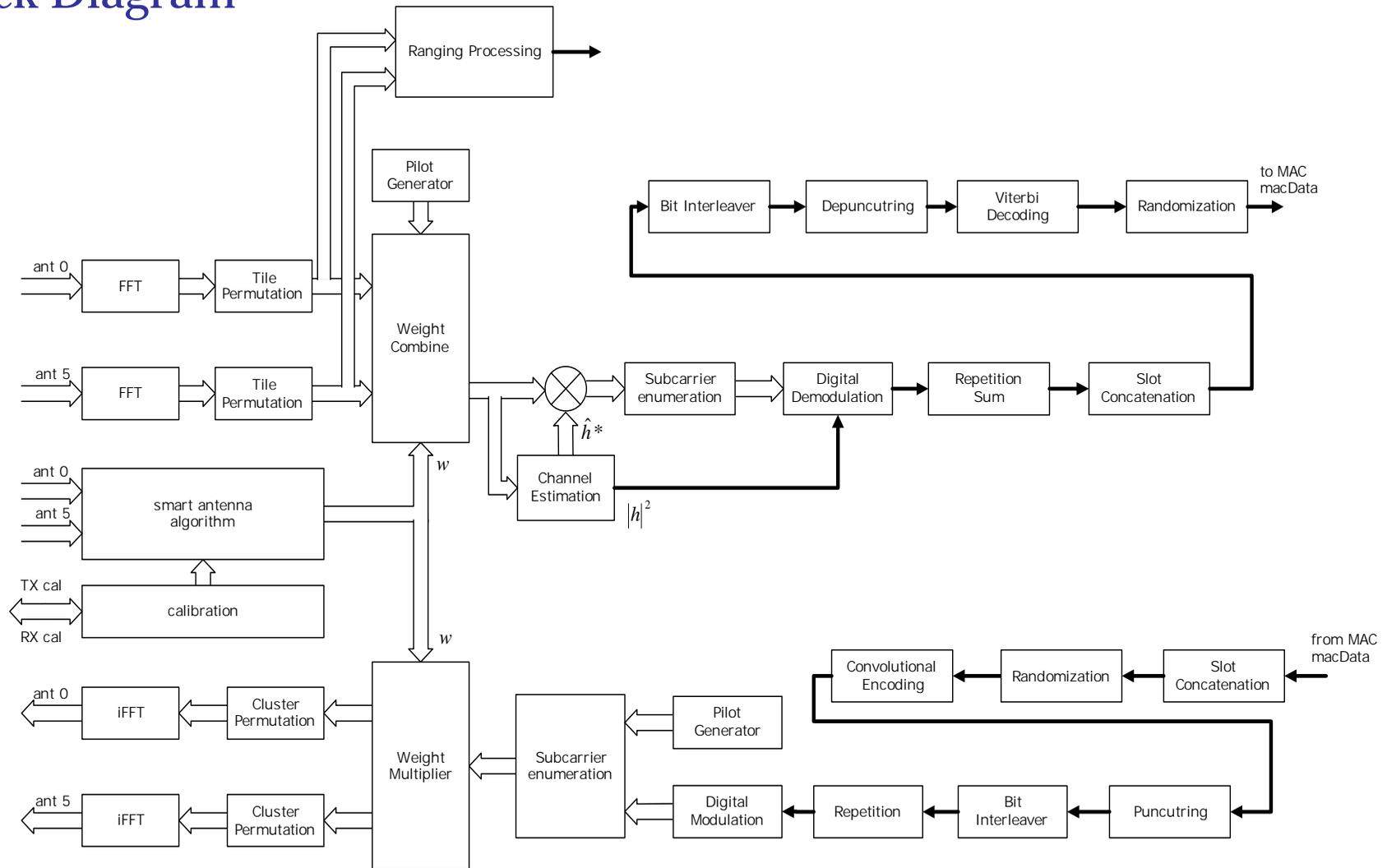
□ PHY specification

		Downlink	Uplink
Number of OFDM symbol per Frame		27	15
Frame Duration (5ms)	DL, UL subframe duration	3.1104 ms	1.728 ms
	TTG + RTG	TTG(121.2 μ s) + RTG(40.4 μ s) = 161.6 μ s	
Effective Bandwidth		5.625 MHz	3.125 MHz
Frame Structure / FFTSIZE / Modulation / Channel Coding		PUSC mode / 1024 point / QPSK / CC(R=1/2, 3/4)	
Capacity		1FA/3sector(2 ant. diversity mode) or 1FA/1sector(6 ant. SA mode)	
H/W platform Features		SA/MIMO Ready, Auto Calibration, Enhanced Ranging, SDR H/W platform	

• CC : Convolutional Code

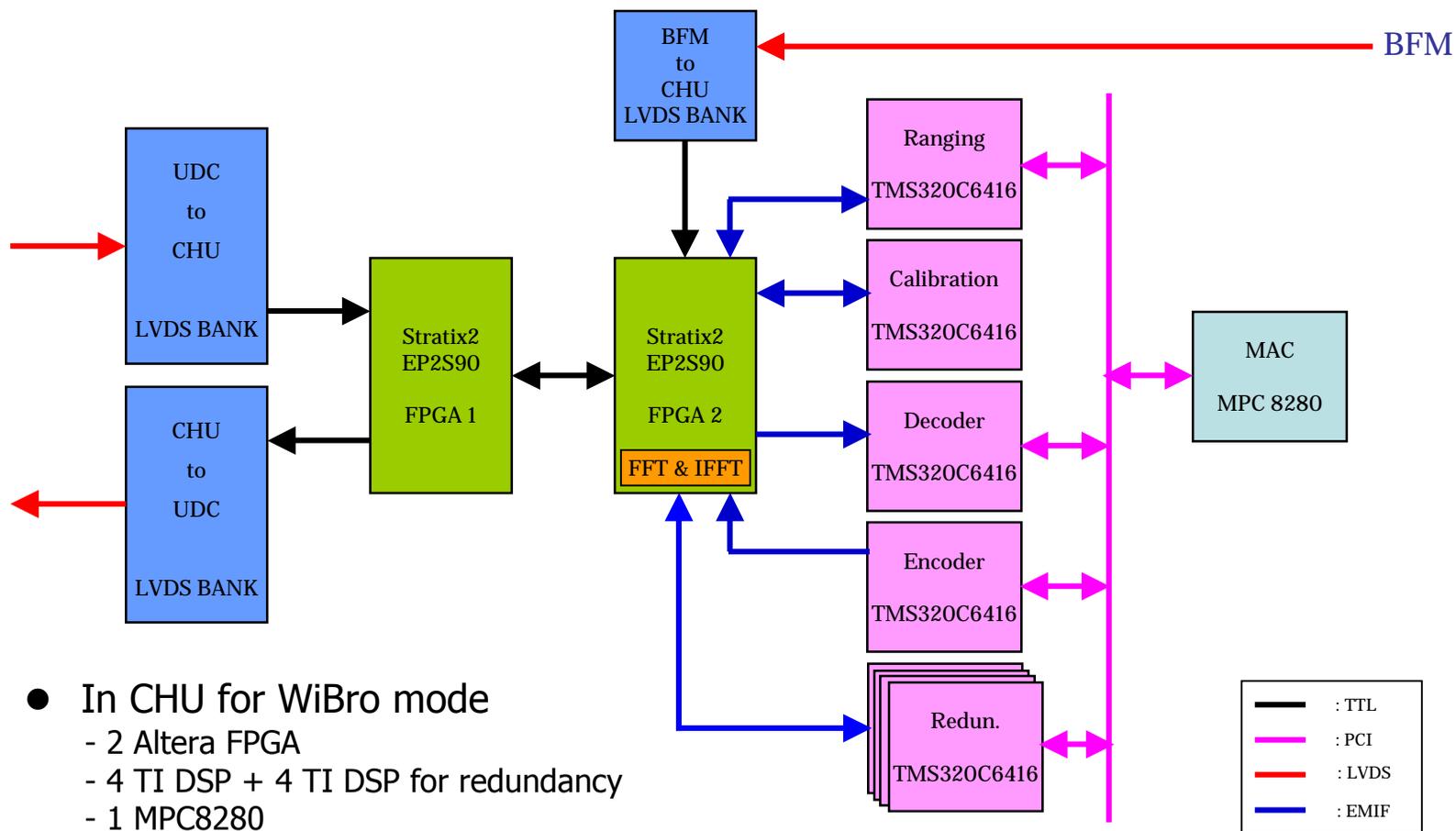
IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● Block Diagram



IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

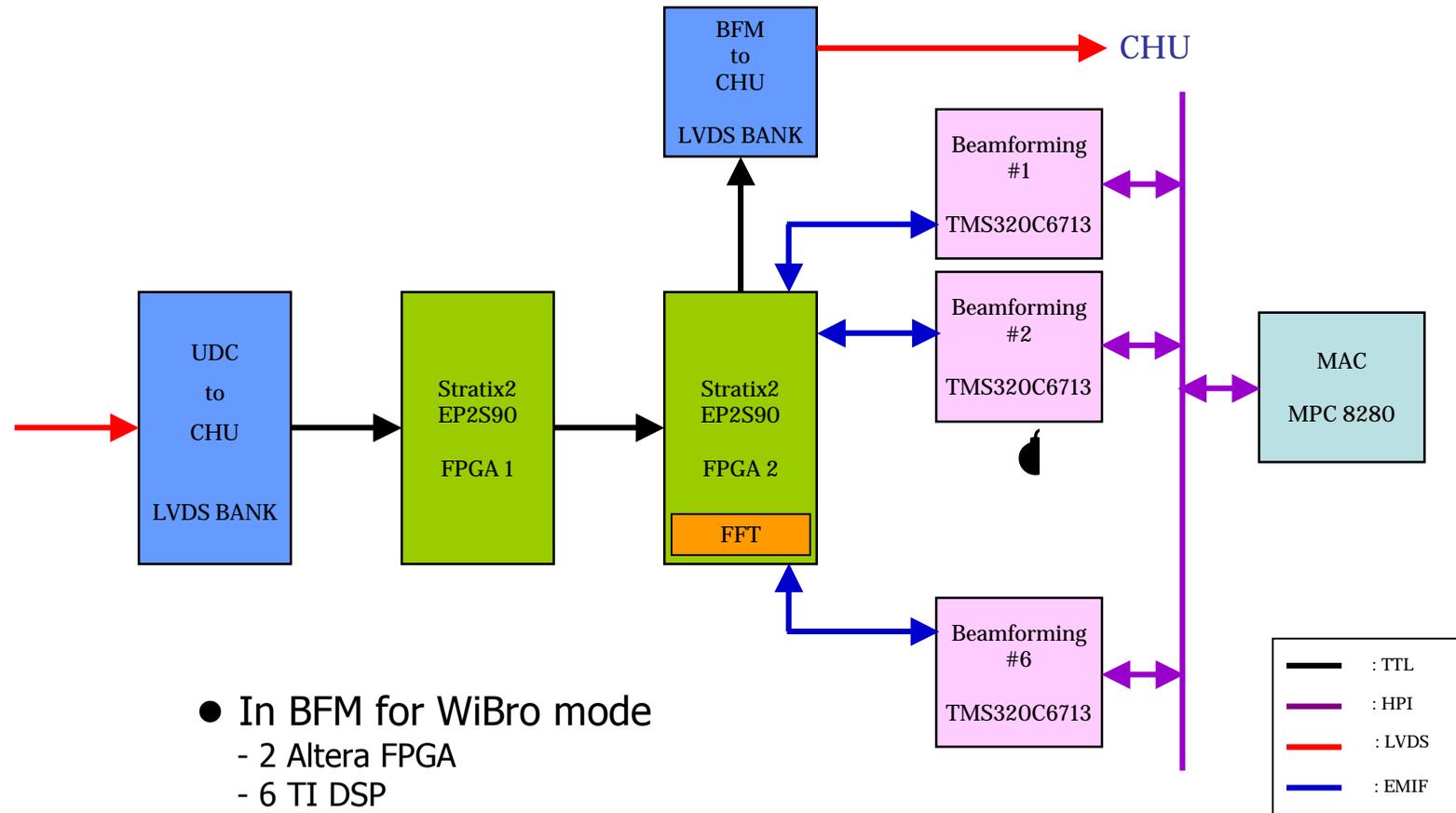
● Channel Card



- In CHU for WiBro mode
 - 2 Altera FPGA
 - 4 TI DSP + 4 TI DSP for redundancy
 - 1 MPC8280

IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● Beamformer



- In BFM for WiBro mode
 - 2 Altera FPGA
 - 6 TI DSP
 - 1 MPC8280

IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● SABS Architecture

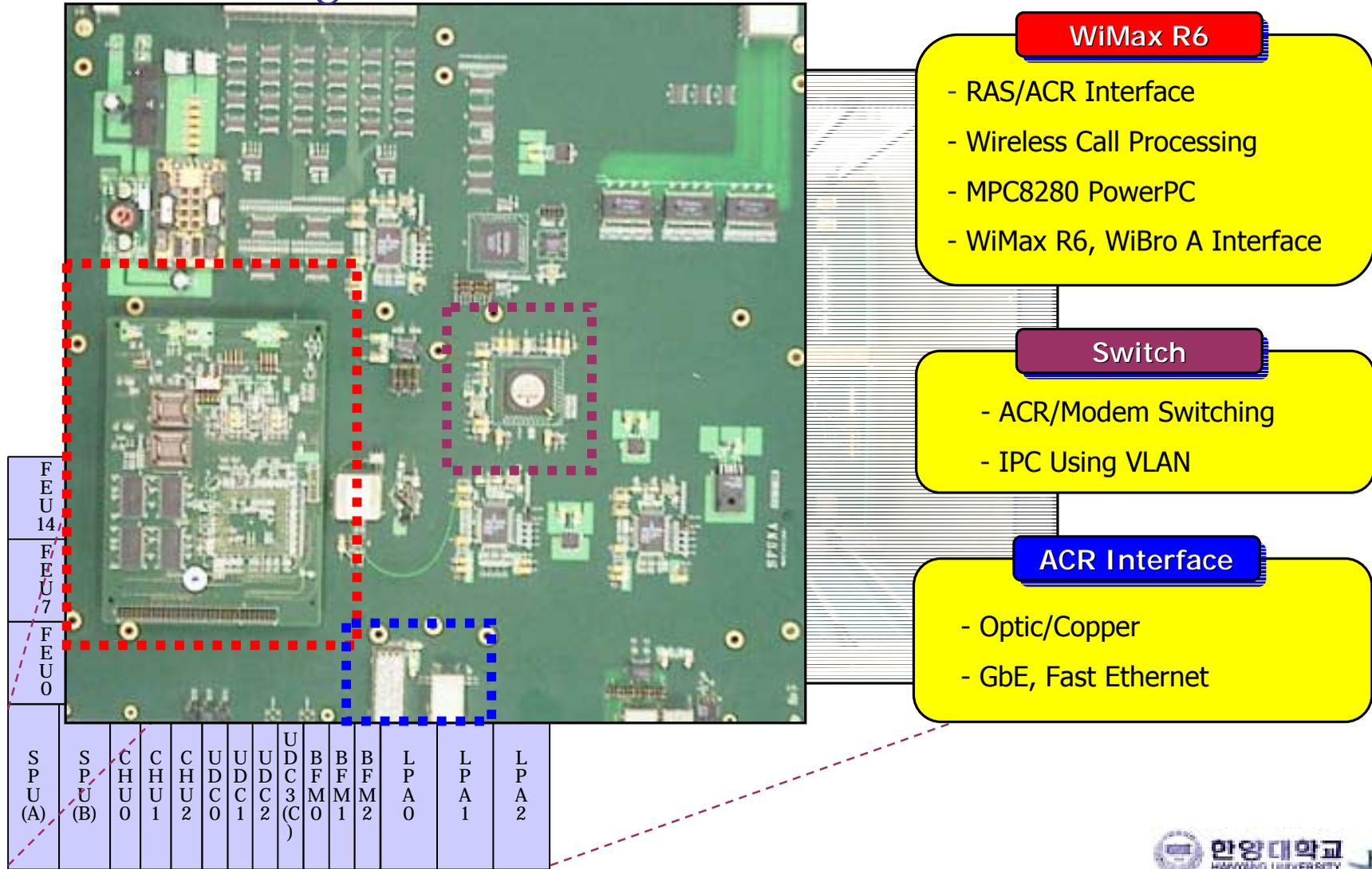
1FA & 3 sector

F E U 14	F E U 15	F E U 16	F E U 17	F E U 18	F E U 19	F E U 20 (γ)								
F E U 7	F E U 8	F E U 9	F E U 10	F E U 11	F E U 12	F E U 13 (β)								
F E U 0	F E U 1	F E U 2	F E U 3	F E U 4	F E U 5	F E U 6 (α)								
S P U (A)	S P U (B)	C H U 0	C H U 1	C H U 2	U D C 0	U D C 1	U D C 2	U D C 3 (C)	B F M 0	B F M 1	B F M 2	L P A 0	L P A 1	L P A 2

- ❑ FEU : Front-End Unit
 - TDD Switch
- ❑ LPA : Linear-Power Amplifier
- ❑ UDC : Up/down Converter
- ❑ CHU : Channel Unit
 - PHY
 - Calibration
 - MAC, Scheduler
- ❑ BFM: Beamforming Module
 - Beamforming
- ❑ SPU : System Processing Unit
 - MAC
 - Access Control Router (ACR) interface

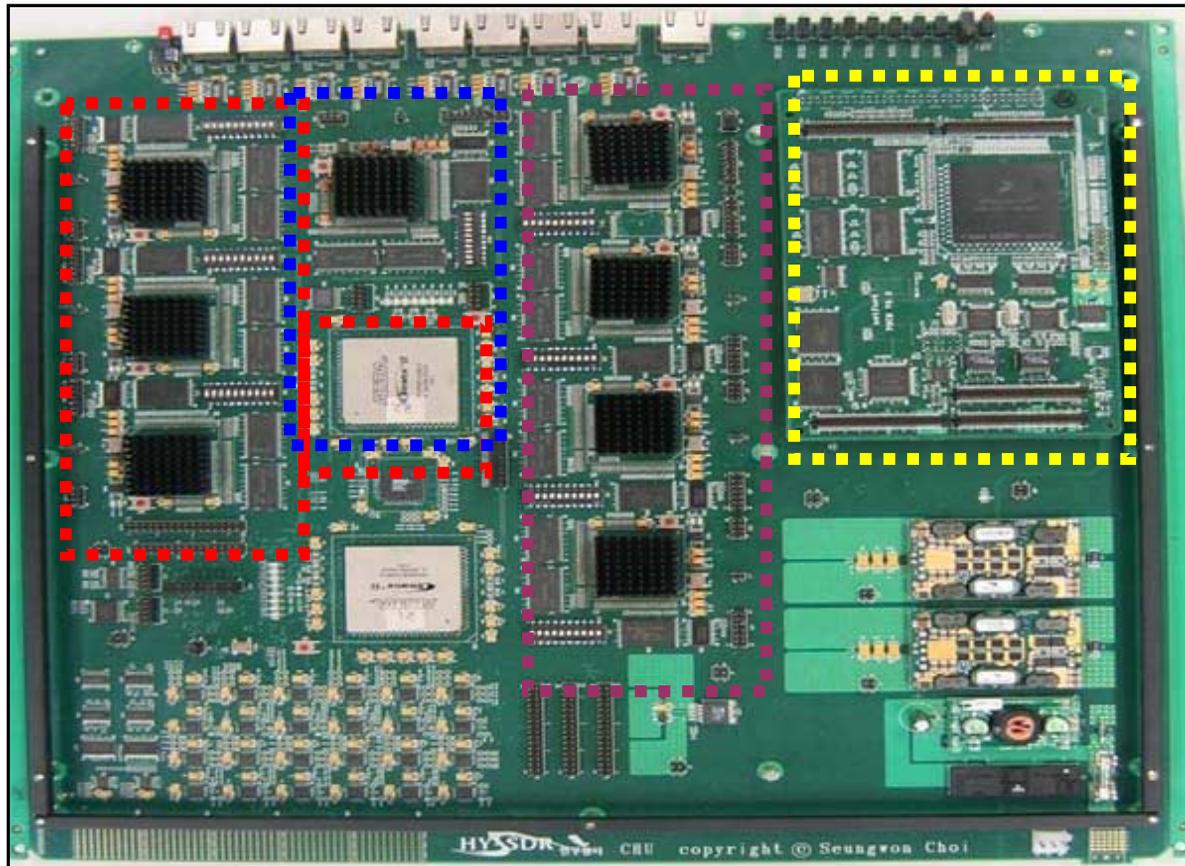
IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● System Processing Unit



IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● Channel Card Unit



UPLINK

- 1024p FFT/15 symbols per frame
- FEC decoder
- Ranging / Calibration
- FPGA_Z2, decDSP, rngDSP

DOWNLINK

- 1024p IFFT/27 symbols per frame
- Downlink beamforming
- FEC encoder
- FPGA_Z2, encDSP

CONTROL

- CHU Control
- MAC Layer

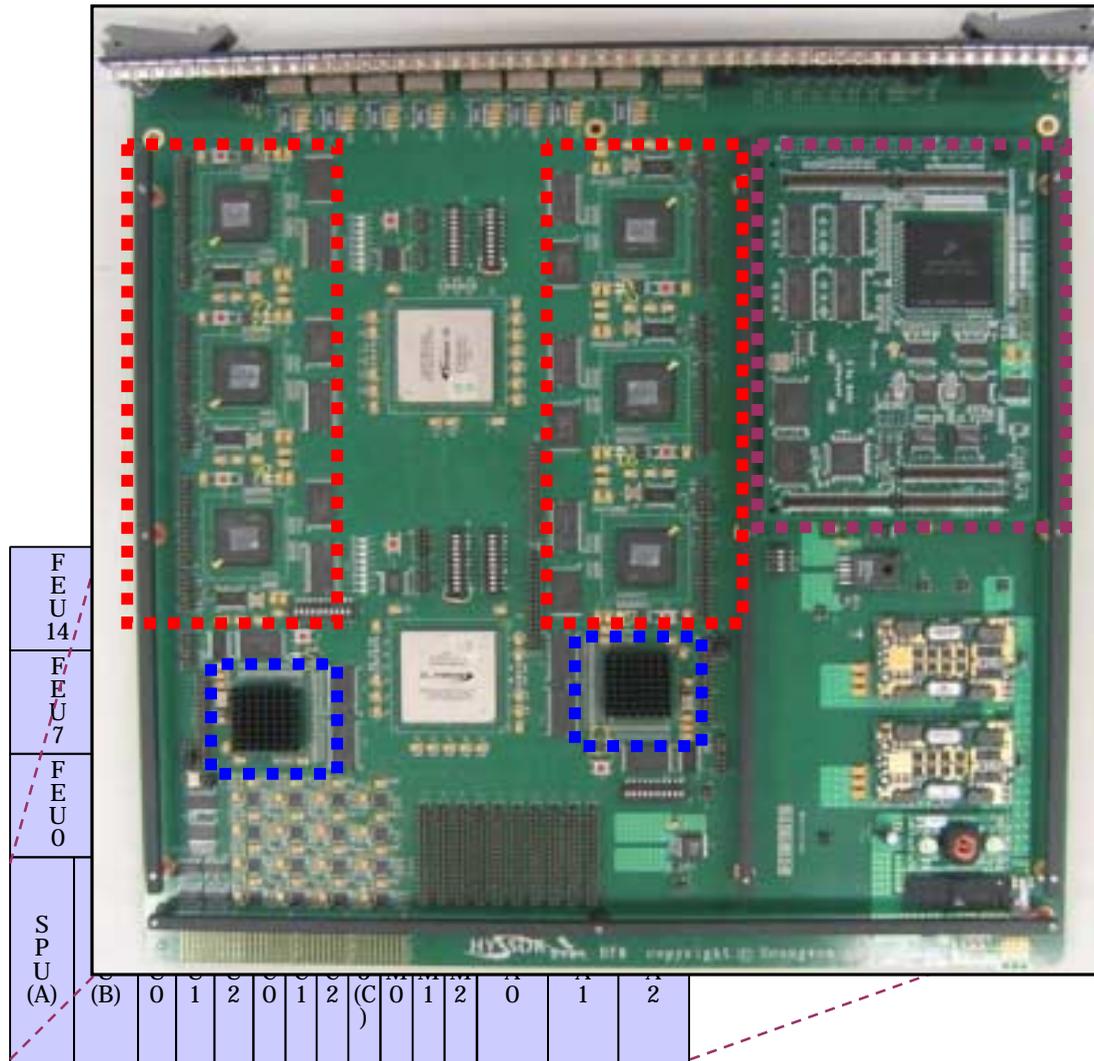
Redundancy

- 4 DSP

S	S	C	C	C	U	U	U	U	B	B	B	L	L	L
P	P	H	H	H	D	D	D	D	F	F	F	P	P	P
U	U	U	U	U	D	D	D	D	M	M	M	A	A	A
(A)	(B)	0	1	2	0	1	2	3	0	1	2	0	1	2
								(C)						

IV. IMPLEMENTATION OF SDR-based WiBro RAS (cont'd)

● Beamformer



BEAMFORMER

- 6 processors per BFM
- Max. SNR criterion
- Real-time beamforming processing
- Support Max. 35 users per 300 μ s (1 UL slot duration)
- bfmDSP

CONTROL

- BFM Control
- SPU Interface

Redundancy

- 2 DSP

V. CONCLUSION

- ❖ SA API is a key factor to realize SDR-based SA system with open architecture.
- ❖ Usecases of SA APIs help understand API's functionality.
- ❖ SA APIs standardization is in progress at SDRF via OMG.
- ❖ SDR-based WiBro SA RAS is implemented with open architecture.