Research on Basic Theories and Key Technologies of Cognitive Wireless Network

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Project Information

National Basic Research Program of China
(973 Program):
Title: Research on Basic Theory and Key Technologies of Cognitive Wireless Networks (2009CB320400)
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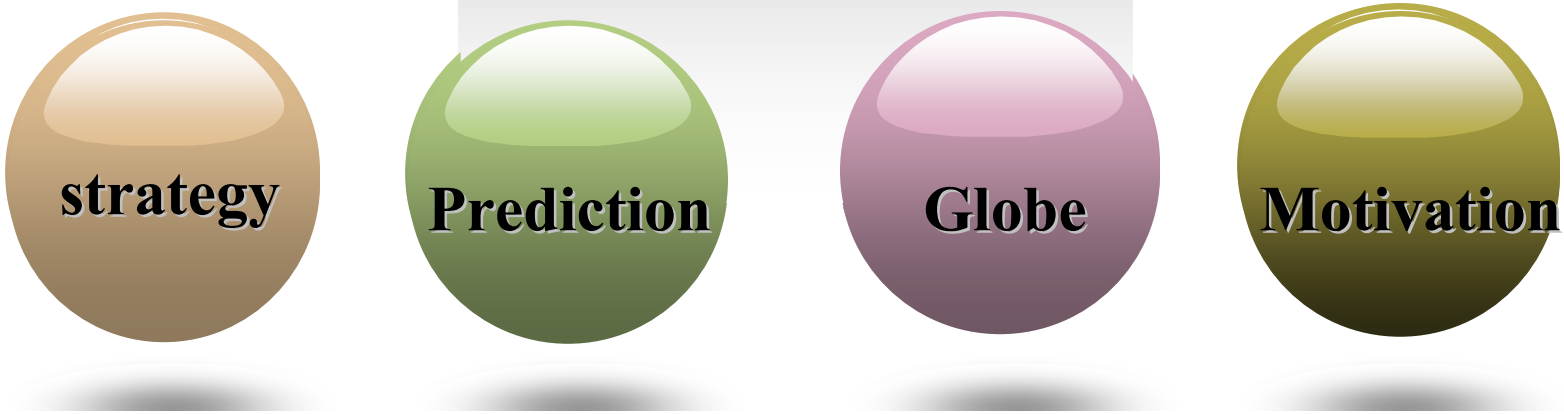
Chief Scientist: Ping Zhang
Funding: 30million Yuan
Number of Partners: Eight

973 Project Introduction

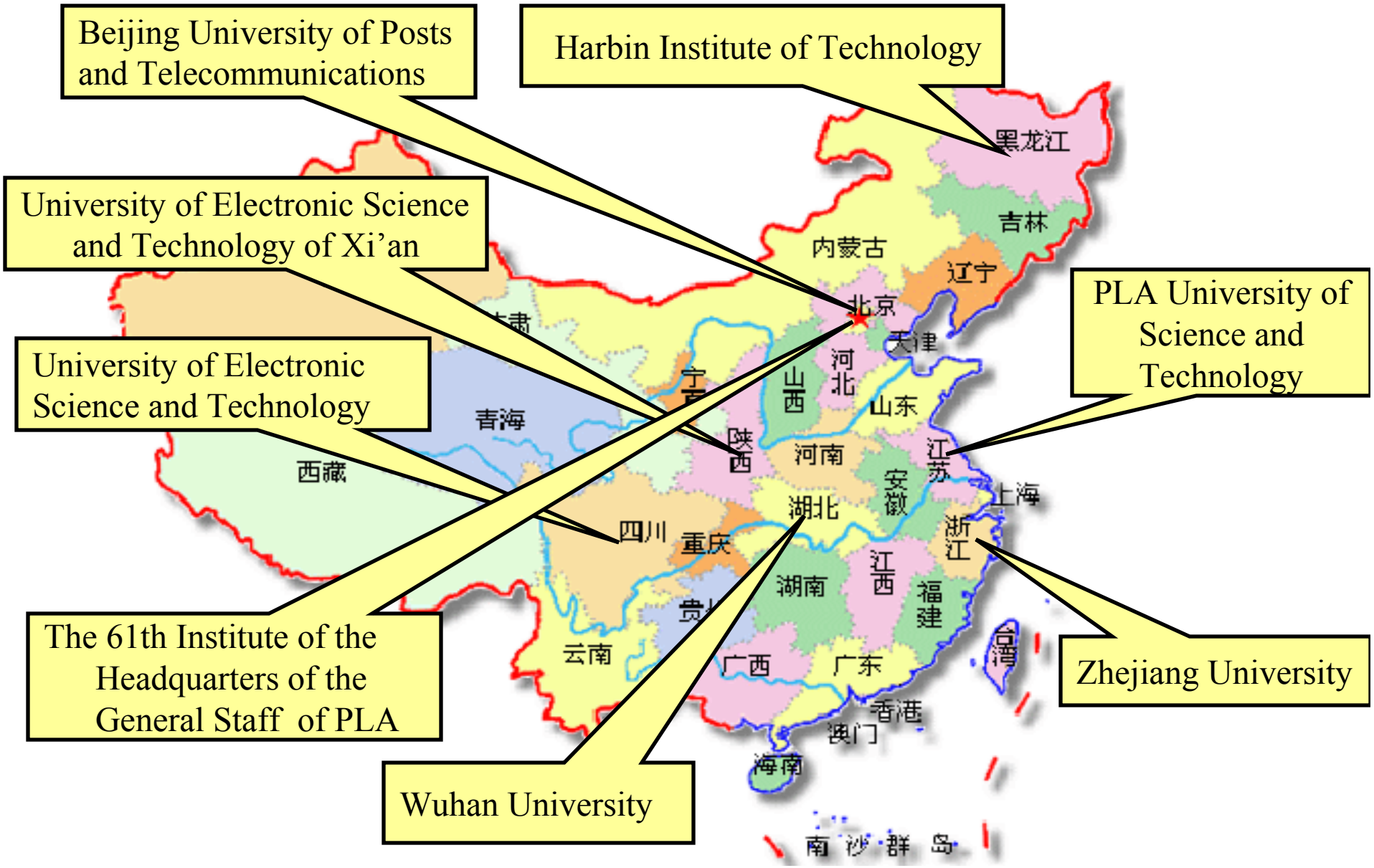
The National Basic Research Program---"973" Project, which has features like strategy, prediction, globe and motivation, is created on the basis of existing research activities and deployments to organize and implement basic research to meet the national major strategic needs as well as to further reinforce basic research and scientific technology work.

development and progress of scientific technology

National Key Basic Research and Development Plans (973 Project)



Project Partners

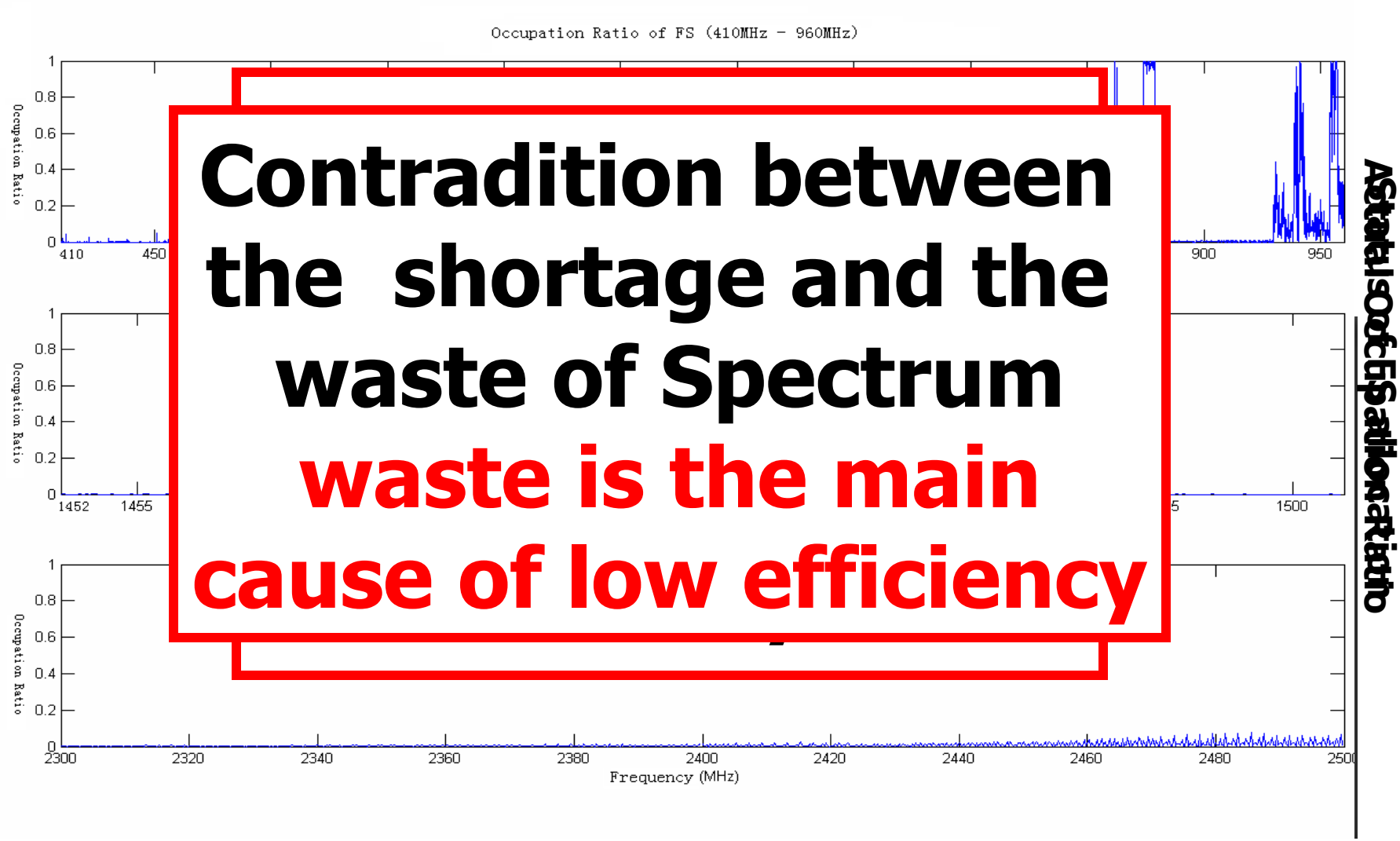


CONTENTS

- Background
- Why CWN and Scientific Issues
- Research Contents and Plans
- Introduction of CWN Demo System

Motivation 1: Requirement of Spectrum

Field test of Spectrum Occupation (Time: from 8 p.m., Mar 16, 2008 to 8 p.m., Mar. 17, 2008. Scenario: typical urban area, Location: BUPT Campus)



Contradition between the shortage and the waste of Spectrum

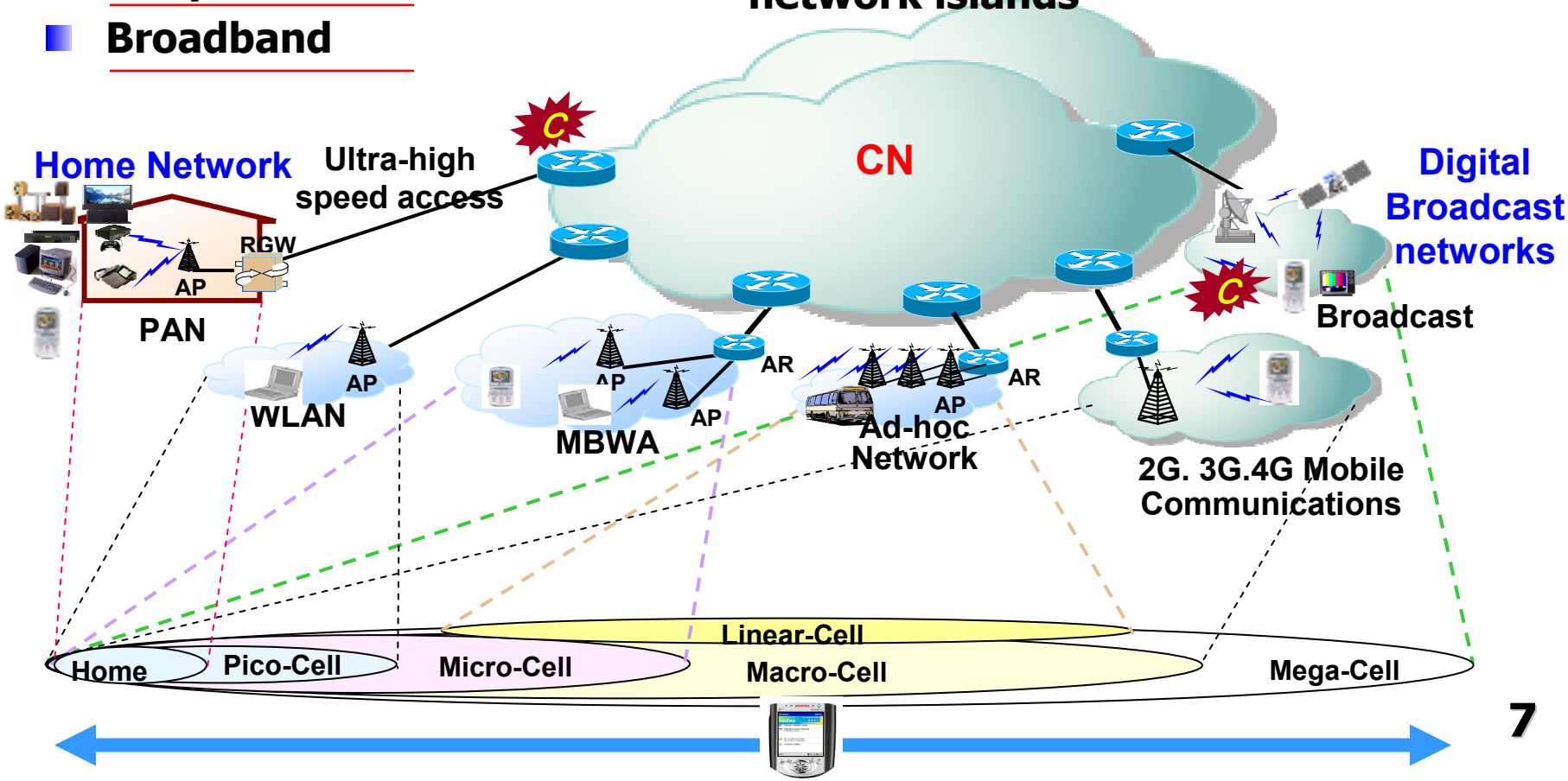
waste is the main cause of low efficiency

Motivation 2: Heterogeneity

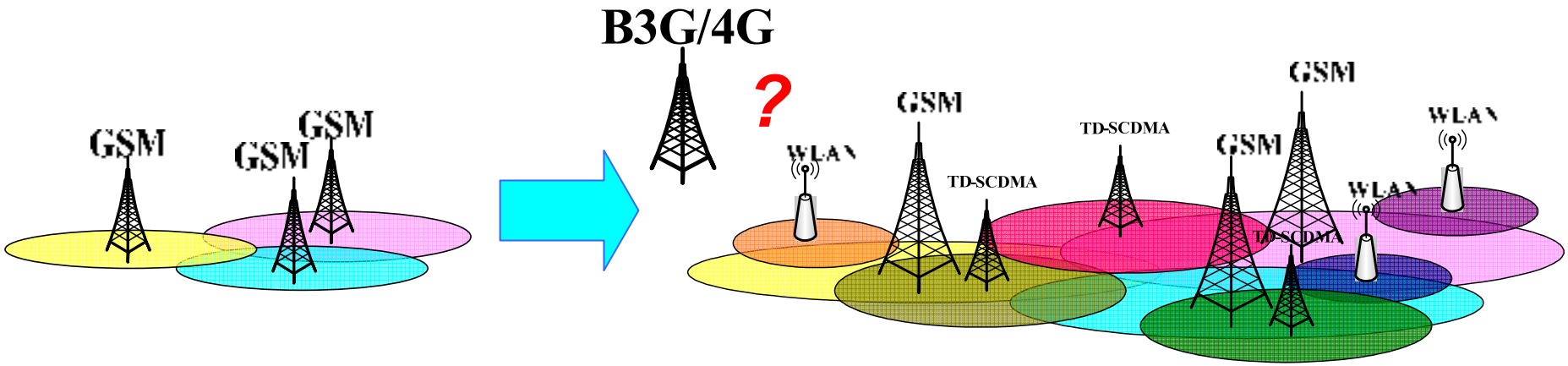
Radio Networks Developing Trend:

- **Heterogeneous**
- **Ubiquitous**
- **Broadband**

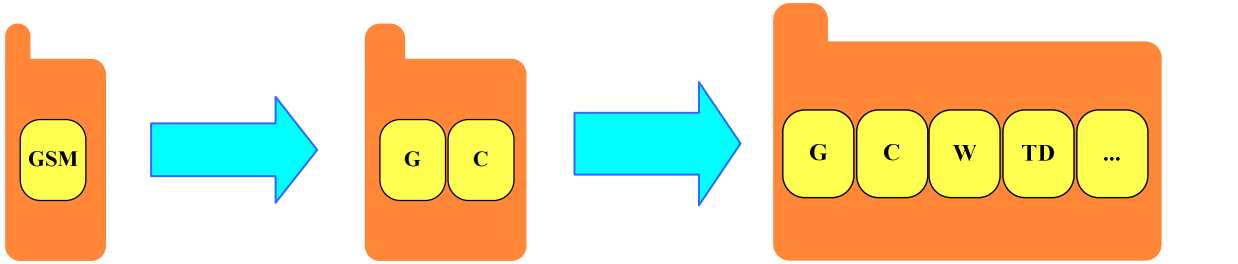
Heterogeneity: distinct architectures, models and schemes of different networks, in accordance with different goal and requirement, lead to various "network islands"



Problems caused by Heterogenerous Wireless Networks



Too many antennas, BSs, causing resource waste and compatibility difficulties



Single-Mode Dual-Mode Multi-mode ?

Current Status of Wireless NW

Increasing demand of user's business requires more resource，especially the scare spectrum，introducing huge challenges to economy, environment and the sustainable development of wireless communication technology.

The duplicate construction and erection due to the coexistence and independence of various RATs leads to much unnecessary waste.

There's an urgent demand for innovation of wireless networks technologies, aiming at dynamic and efficient use of resource and energy, and solve the issues on heterogeneous wireless networks.

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Analysis of the Essential Problem

Problems

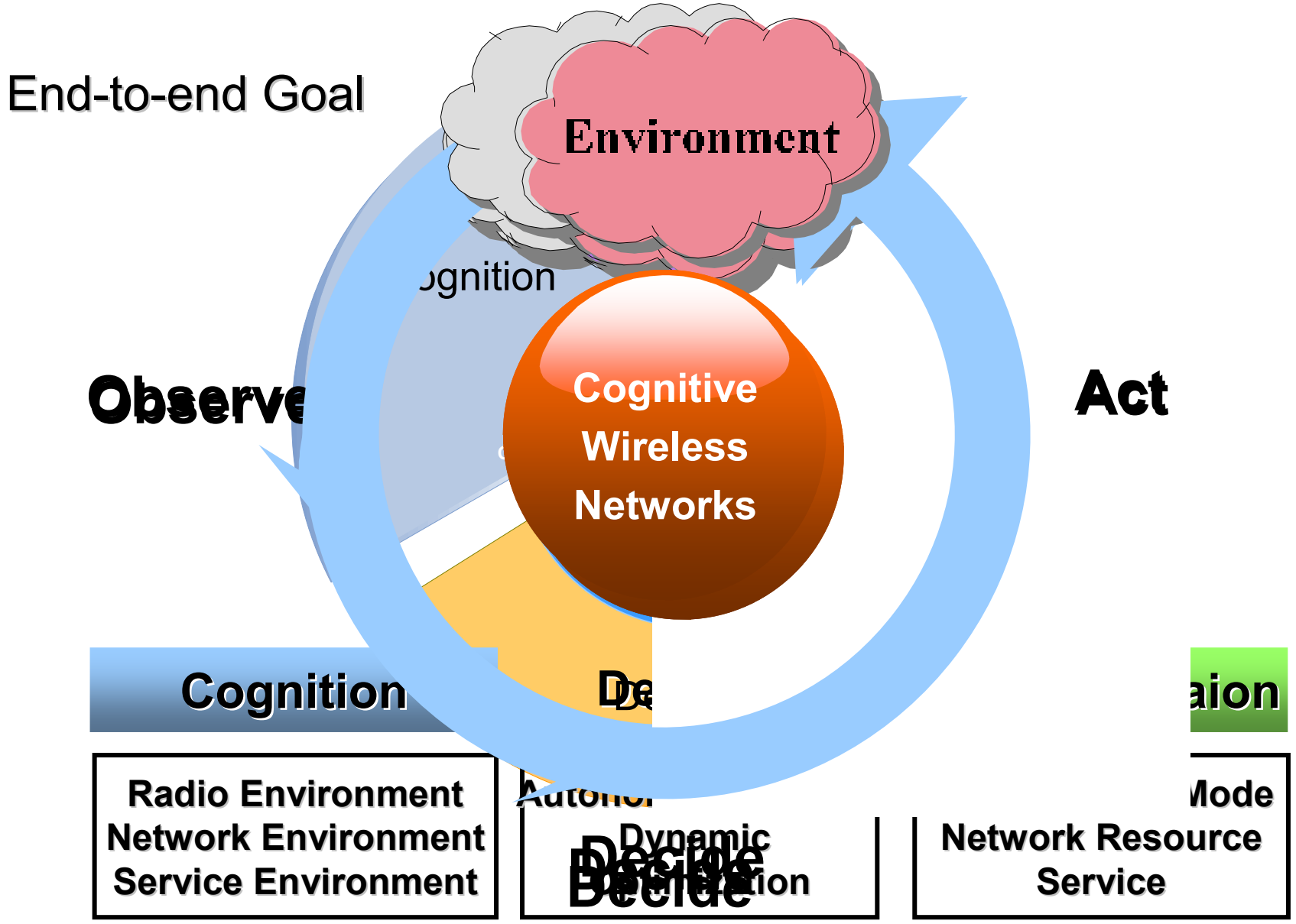
Scarcity and Waste of Spectrum

Failure of Wireless NWs to [illegible]nverge

Solution?

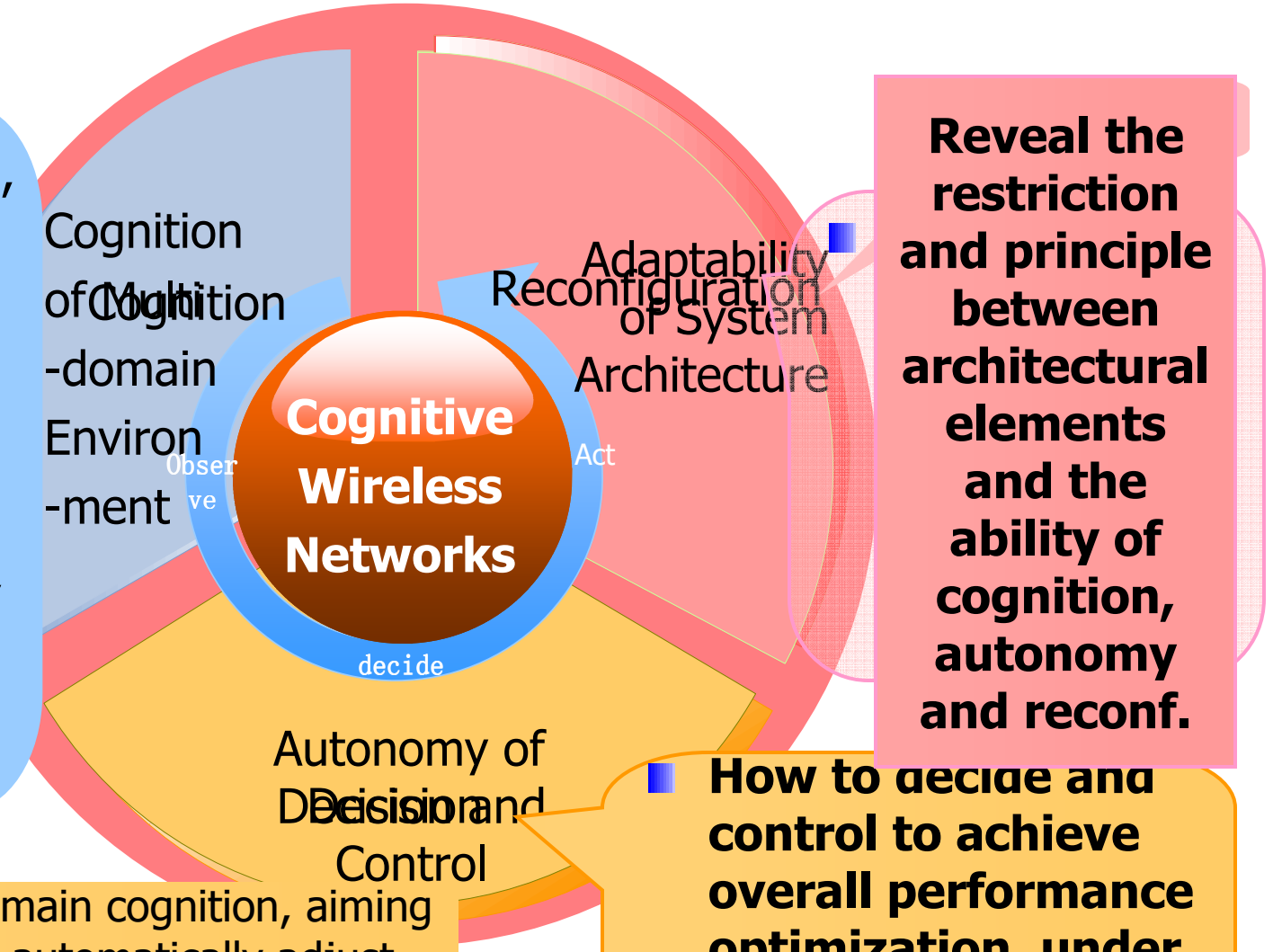
How can wireless NW Adapt to complex dynamic environment

What is Cognitive Wireless Networks (CWN)



Proposition of Scientific Issue

- How to acquire, express, communicate and utilize the cognitive info. among multi-domain including radio, networks and users environments



Reveal the restriction and principle between architectural elements and the ability of cognition, autonomy and reconf.

- **How to decide and control to achieve overall performance optimization, under complex dynamic environment?**

According to multi-domain cognition, aiming at end-to-end goal, automatically adjust elements in NW in order to adapt to complex dynamic environment

Two Definitions

- Cognitive radio: Radios that change the parameters of transmitters based on its interaction with environments.

  ——Joseph Mitola proposed for the first time in 1999

- Cognitive Wireless Networks (CWN): wireless networks that change network features based on its interaction with multi-domain environments.

  —— Our definitions

  - Our definitions suggest wireless networks with
    - cognitive functions (intelligence);
    - Optimizing aims at global optimization of end-to-end purpose;
    - Cognizing is active and in multi-domain;
    - Network components can be reconfigurable.

  - We suggest solve problems of resource utilization efficiency and convergence of heterogeneous networks

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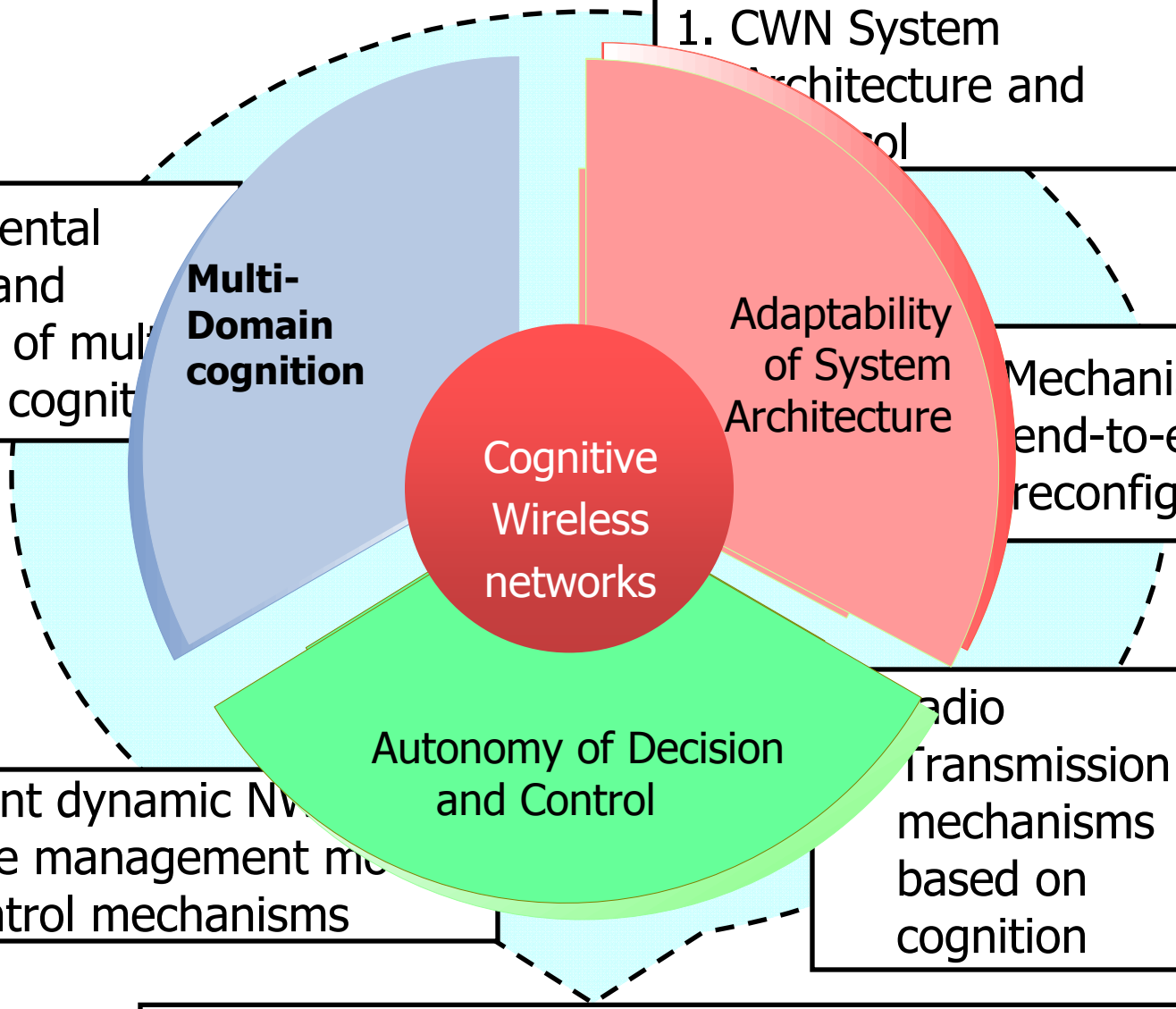
Research Contents



1. CWN System
rchitecture and
ol

2. Fundamental theory and method of mul
domain cognit

Mechanisms of end-to-end reconfiguration

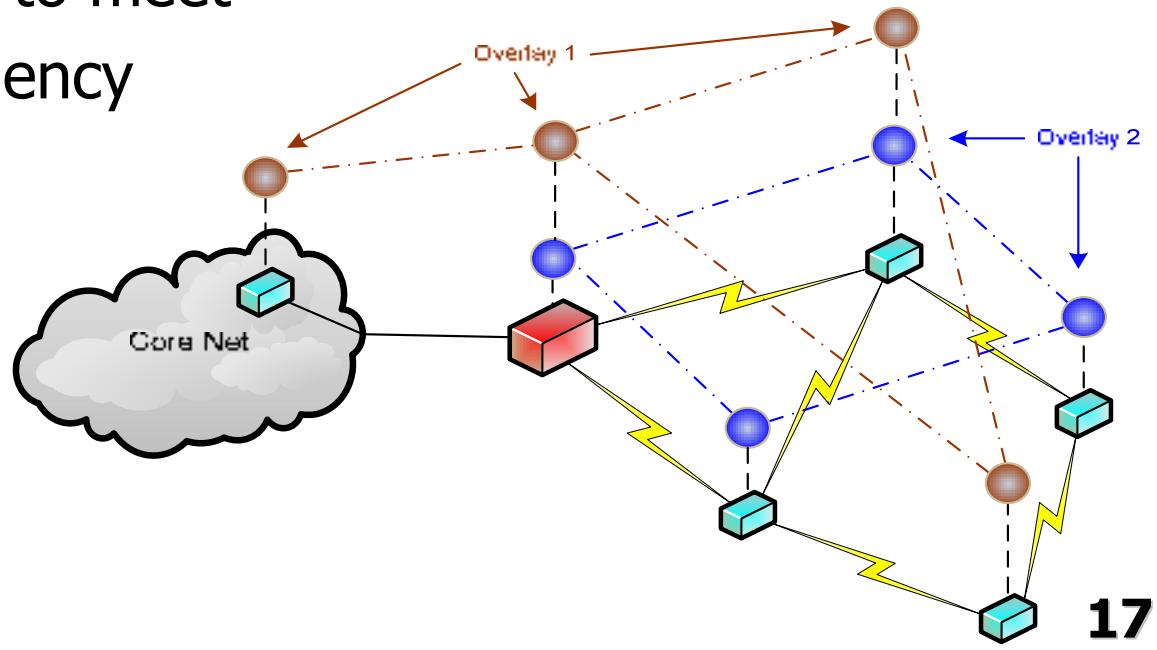
adio Transmission mechanisms based on cognition

3. Intelligent dynamic NW resource management me and control mechanisms

6. Construction and experiment of CWN test bed

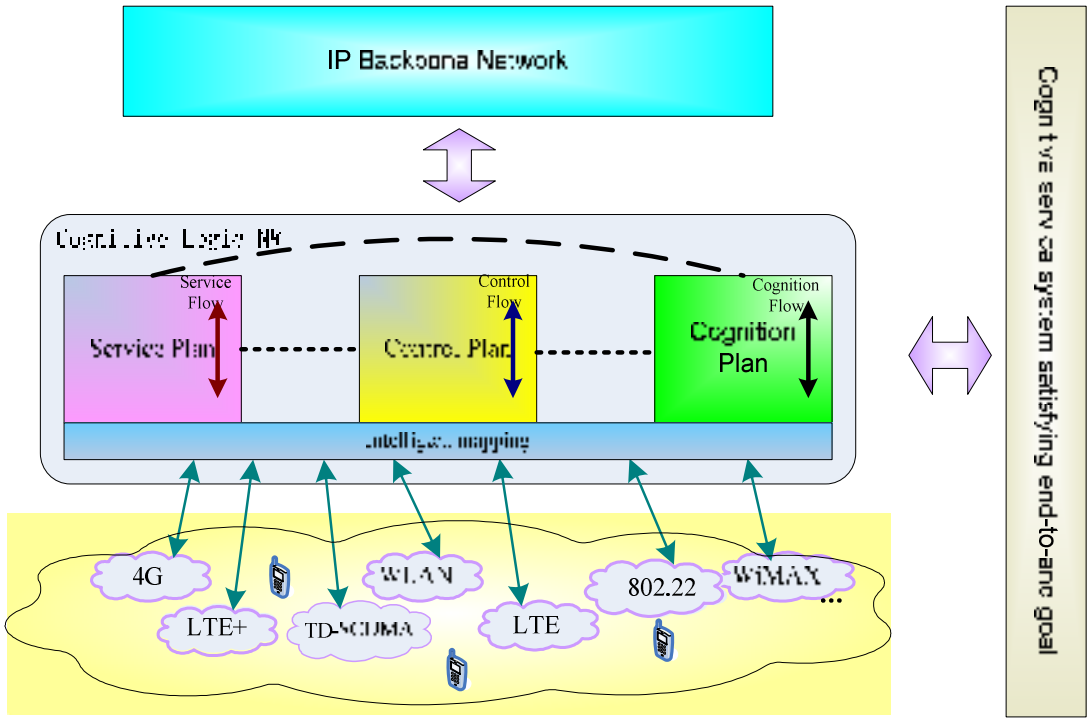
（1）Research on Cognitive Wireless Networks System Architecture and Protocol

- Contents of the research
  - Design of multi-plane cognitive networks architecture
  - Design of protocol prototype with cognitive、self-control and reconfiguration ability performance optimization of cognitive networks
  - QoS Architecture to meet end-to-end efficiency



（1）Research on Cognitive Wireless Networks System Architecture and Protocol

Research Plan



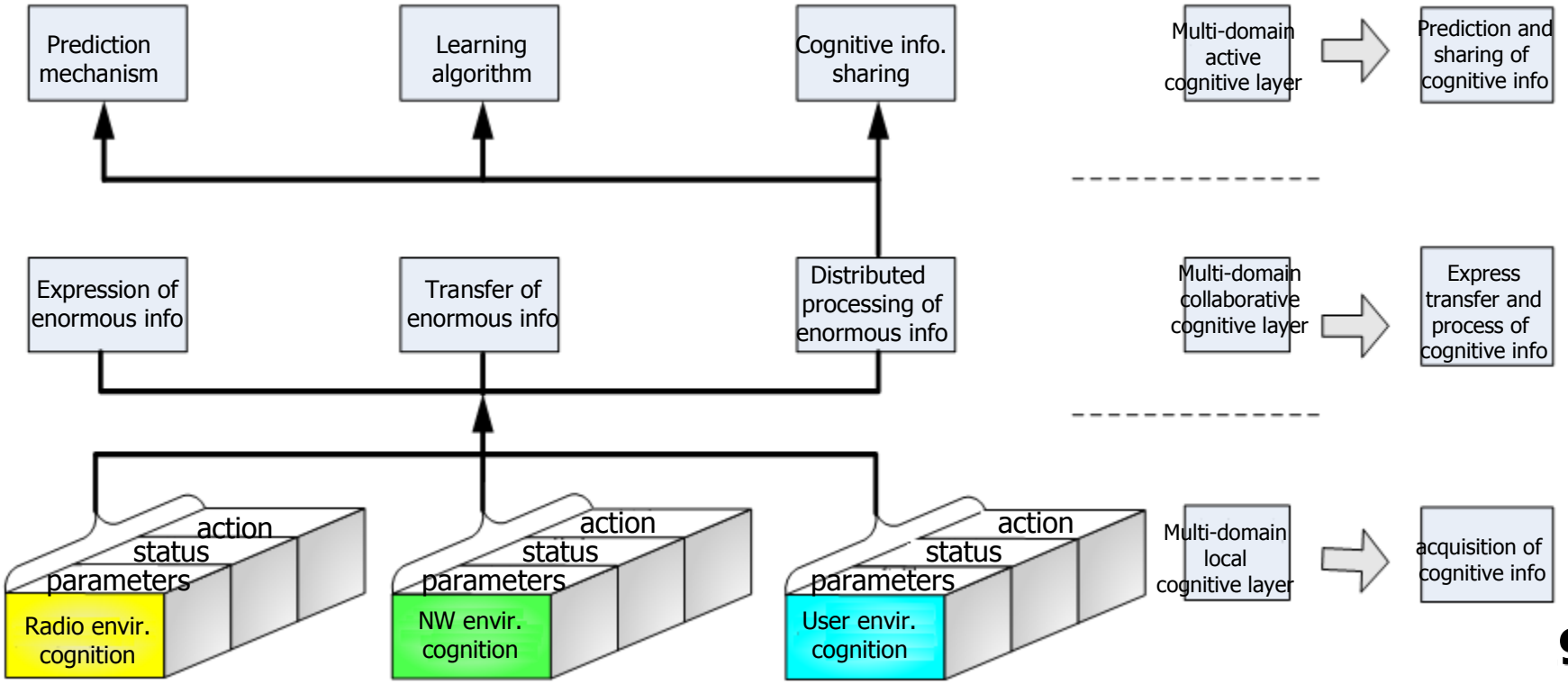
Cognitive service system satisfying end-to-end goal

- Under the frame of cognitive service system satisfying end-to-end goal, separating different planes, to build up a heterogeneity-convergence architecture supporting cognition, autonomous resource management and reconfigurability

（2） Research on Fundamental Theory and Method of Multi-domain cognition

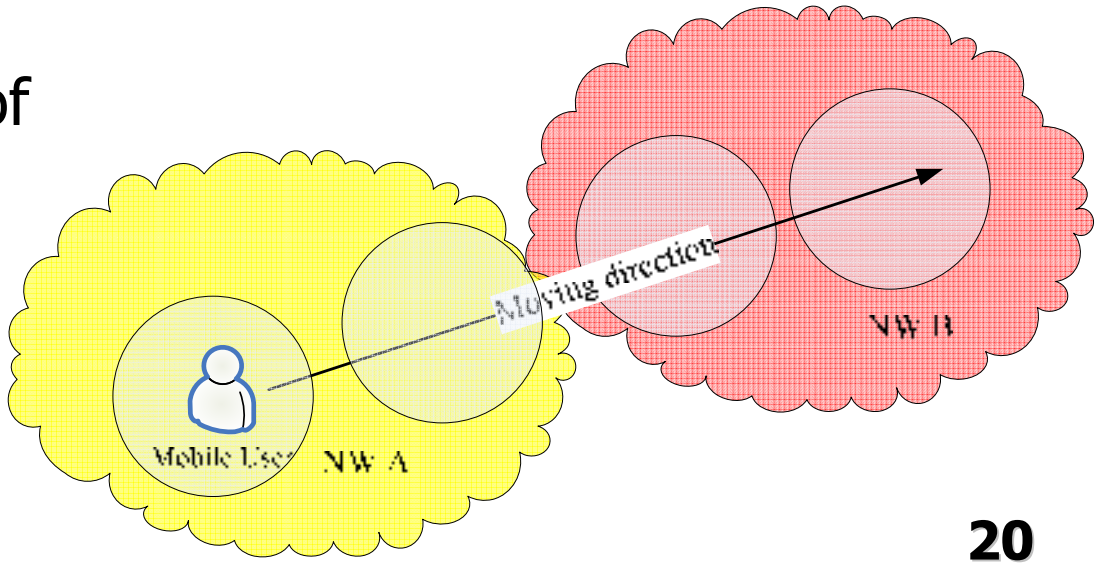
Research Plan

- **Multi-domain cognitive environment oriented**
- **To construct a 3-layer theoretic frame**
- **To research on theories and methods of acquisition, express, transfer, process and prediction of multi-domain cognitive information**
- **To make a leap from single-domain to multi-domain**



（3）Research on Intelligent Dynamic NW Resources Management Model and Control Mechanism

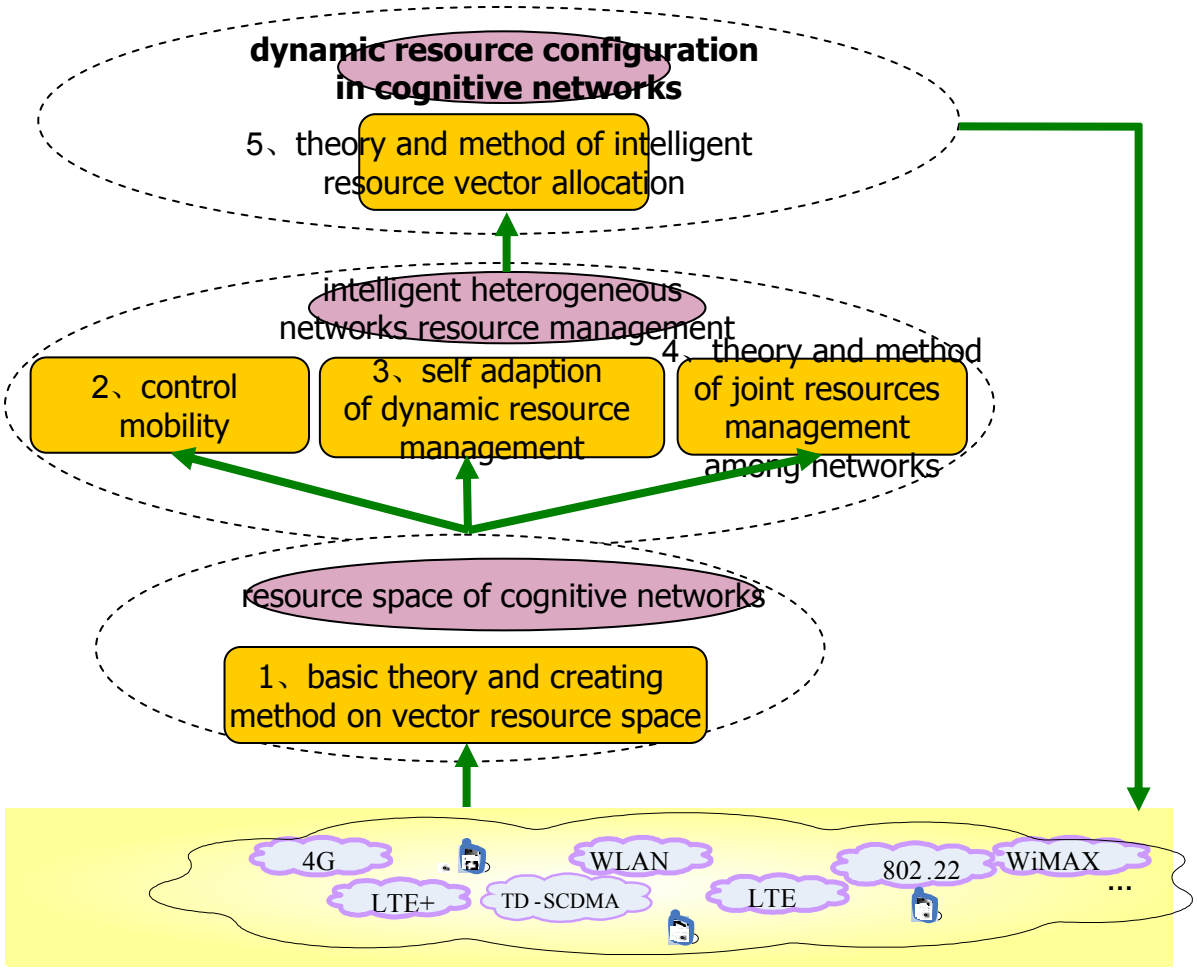
- Contents of research
  - Basic theory and construction of Resource Vector Space
  - Theory and method of "Resource Mobility" Control
  - Autonomous Decision Model and mechanism of Dynamic resource management
  - Theory and method of Inter-network Joint Resource Management
  - Theory and method of Intelligent Resource Vector Allocation



（3） Research on Intelligent Dynamic NW Resource Management Model and Control Mechanism

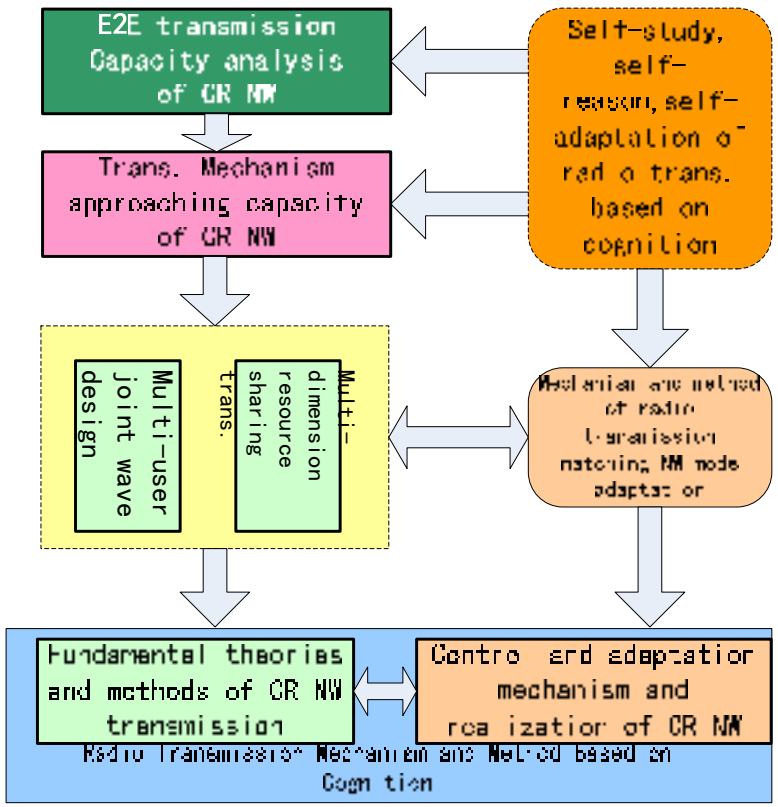
Research Plan

- Aim to raise end to end efficiency, starting with creating vector resource space, do research on theory and methods about resource management in intelligent networks; achieve the goal of dynamically configuration of radio resource in cognitive networks



（4）Research on Transmission Mechanism based on cognition

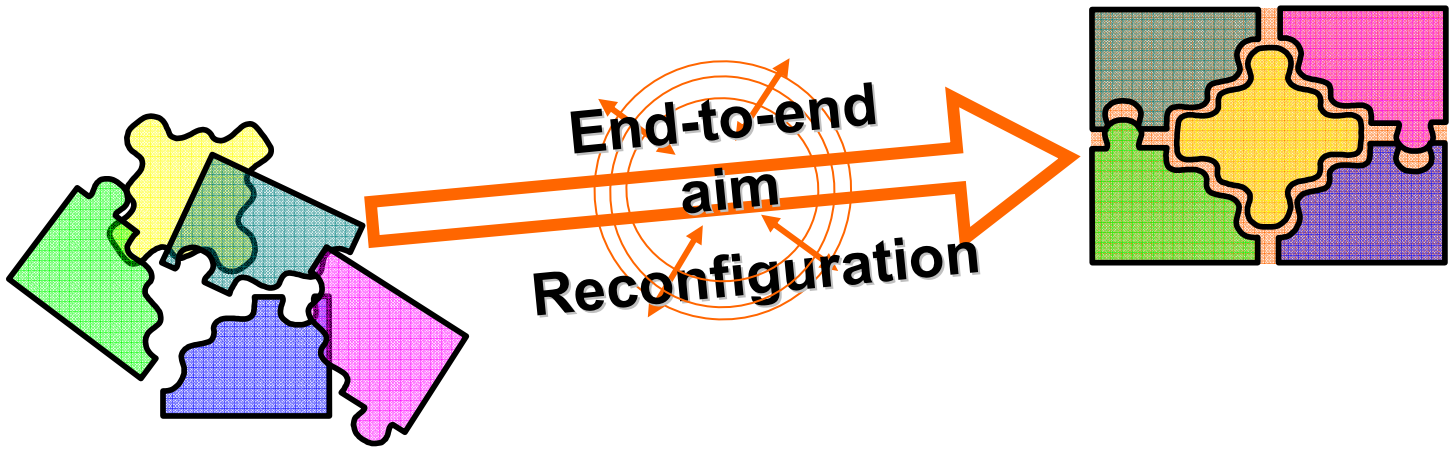
Contents of research



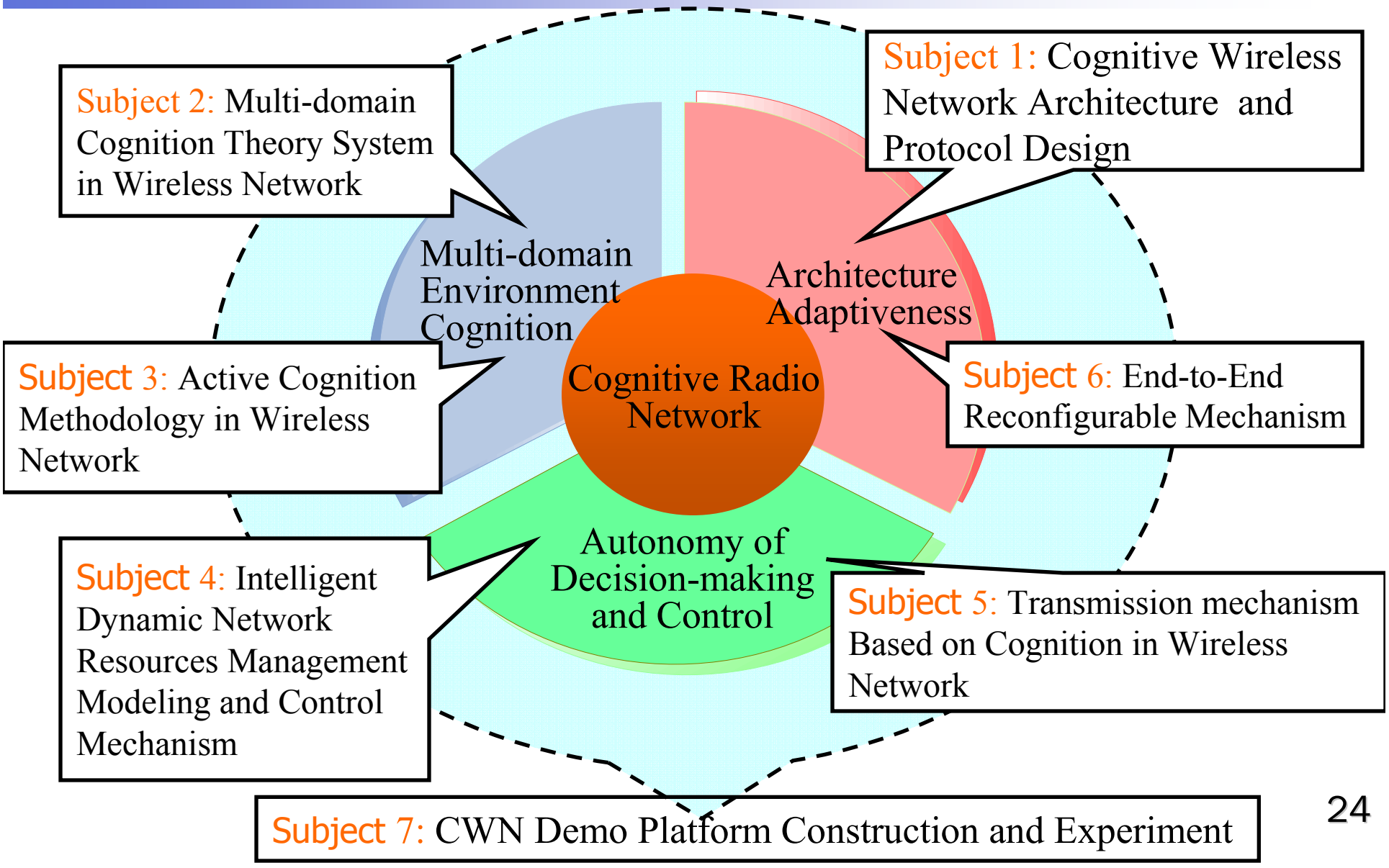
- Analysis of transmission capacity in cognitive wireless networks
- Transmission mechanism of cognitive wireless networks approaching transmission capacity
  - **Design of multi-user joint signal**
  - **Multi-dimension Resource sharing transmission**
- Autonomous control and mechanism of transmission in cognitive wireless networks

（5）Research on Mechanism of End-to-End Reconfiguration

- Research contents:
  - Framework of end to end reconfiguration management and creating methods.
  - The decomposition of particle size and function reconstruction of network action
  - Network and protocol reconfigurability and reconfiguration principles
  - Assess principles of reconfiguration efficiency, security and so on.



Research Contents



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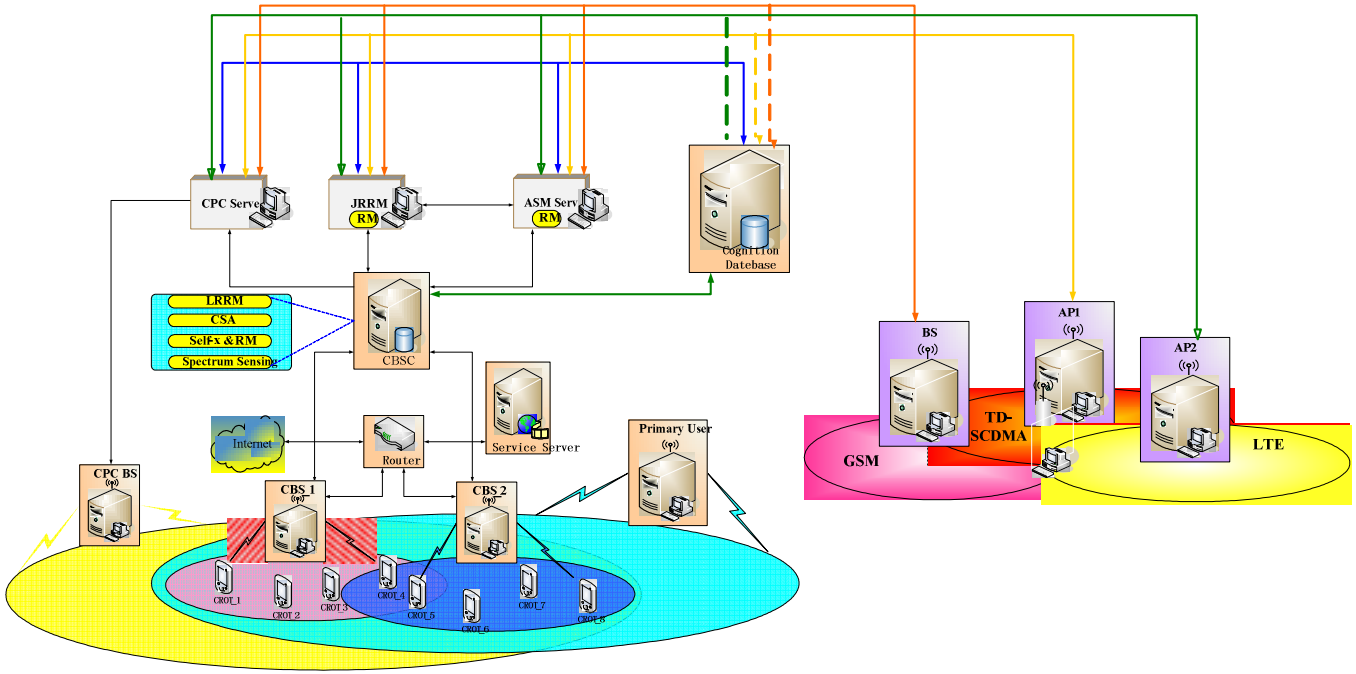
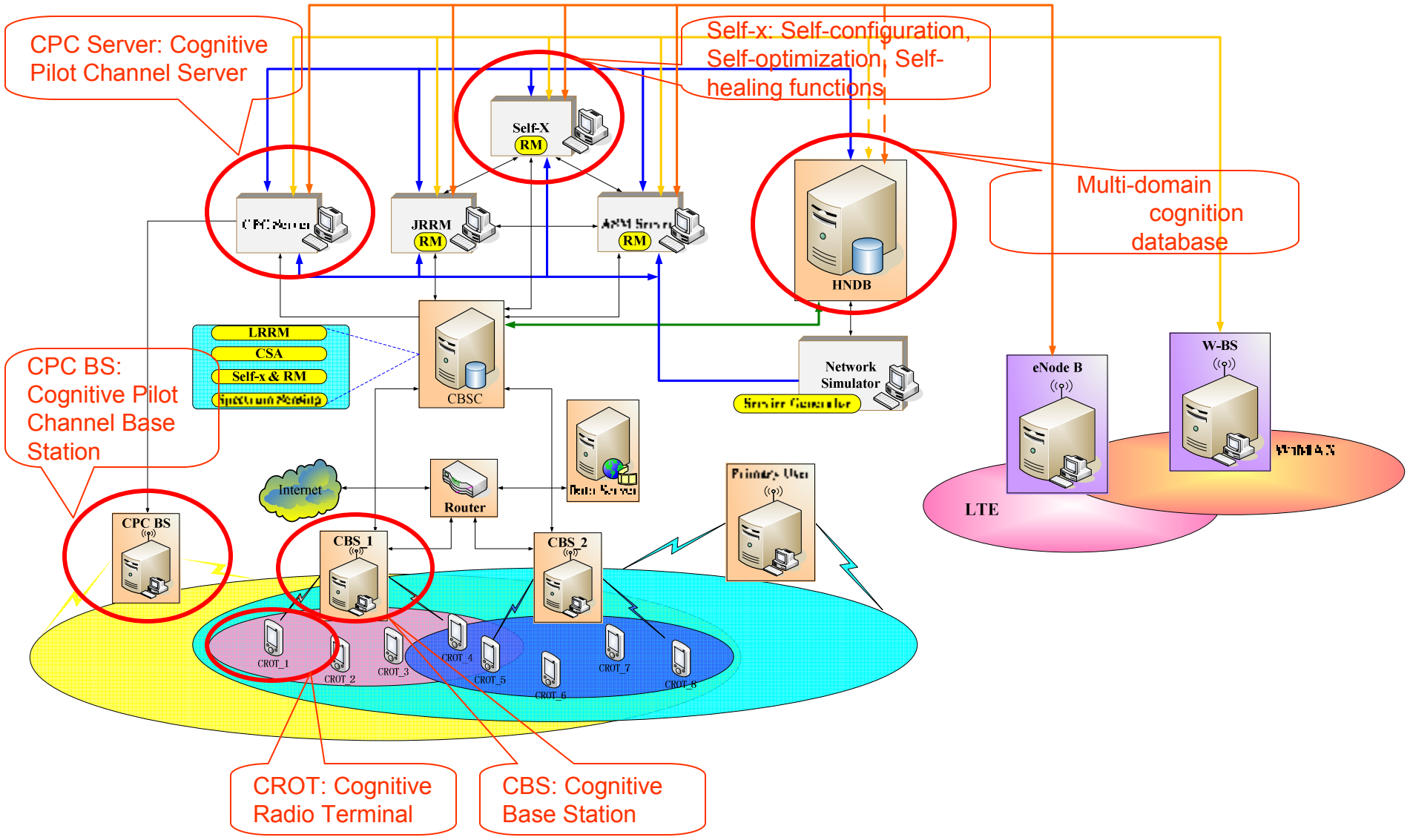
Purpose and Architecture

- Purpose
  - to verify the heterogeneous network convergence and spectrum usage efficiency improvement .
- Architecture
  - mainly made up of the network side, base stations, terminals and other components.

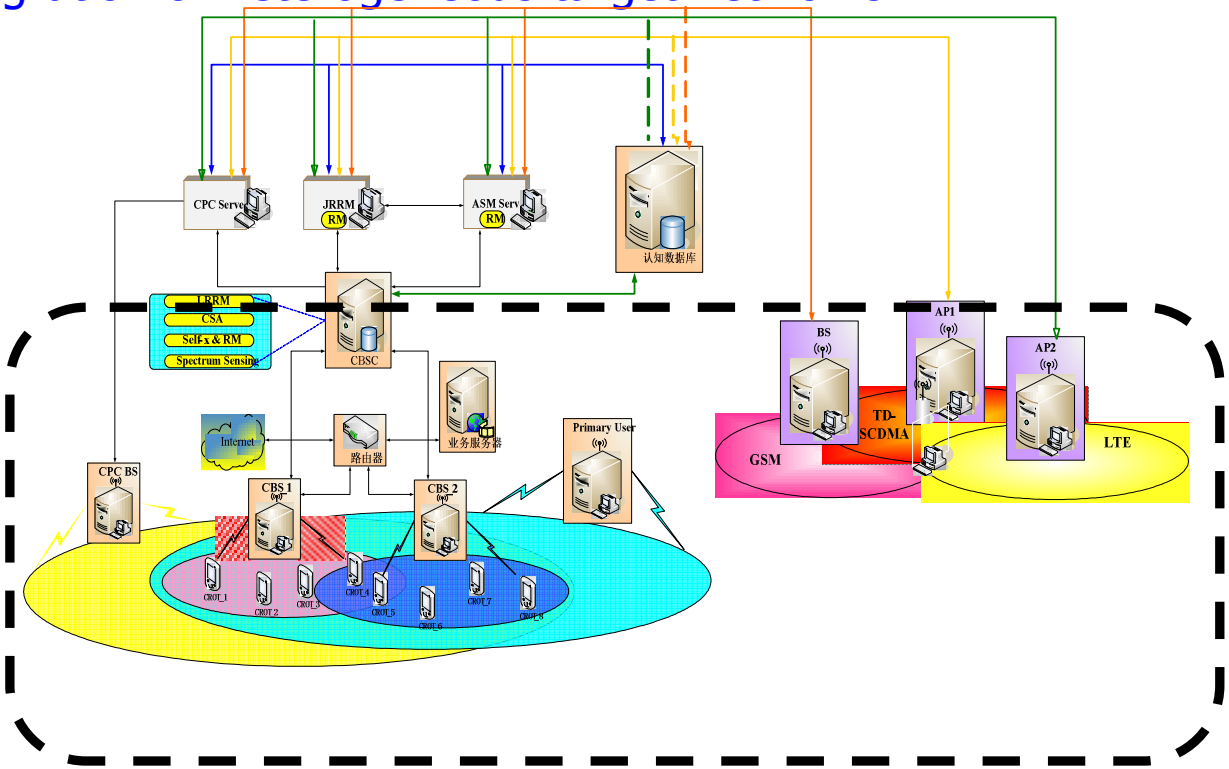


Cognitive Wireless Network Demo System Architecture



Platform Architecture Introduction （1）

- Platform logical entities--Wireless Access , including：
  - Cognitive wireless access network working in cognitive spectrum , including two base stations and eight cognitive terminals, to support the dynamic spectrum access and spectrum aggregation.
  - Heterogeneous wireless access network environment , including LTE, TD-SCDMA, GSM / GPRS network such as the seamless integration of heterogeneous target networks

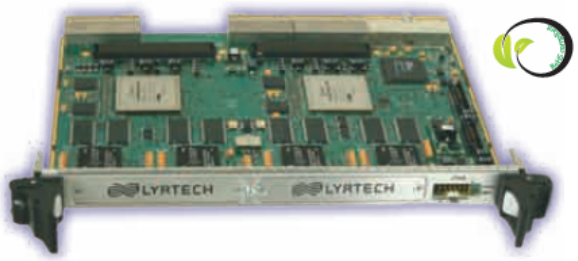


Validation and demonstration platform -- Cognitive access system

- Working Band ： 2.3-2.4GHz (shared-band of IMT-A and Radar)
- Primary User：Radar
- Cognitive User：TD-LTE-Advanced System
- Scene Description ：
  - Verify the cognition of the multi-domain environments.
  - Verify the dynamic spectrum utilization mechanisms and joint radio resource management mechanisms .
  - Verify reconfigurable wireless transmission technology.

Platform Function Entities Introduction

- Cognitive wireless communication transmission system design
  - PHY Design——Based on LTE R8/R9/R10 PHY basic parameters：
    - ✓ Band：20MHz
    - ✓ Data rate (single antenna)： 25~30Mbps
    - ✓ Duplex mode： TDD
    - ✓ Modulation mode：Data--16QAM， Control Signal--BPSK or QPSK
    - ✓ Encoding mode：Data--Turbo，Control Signal--Convolution or Turbo(Considering the realization, using the same encoding mode will be simple , whatever it depends on the needs)
    - ✓ Multiple Access： Uplink--SC-FDMA，Downlink--OFDMA
  - MAC-RRC Design——Based on 3GPP R8/R9/R10 high-layer Protocols



Baseband Unit

Intermediate Frequency Unit

RF Module

Platform Architecture Introduction （2）

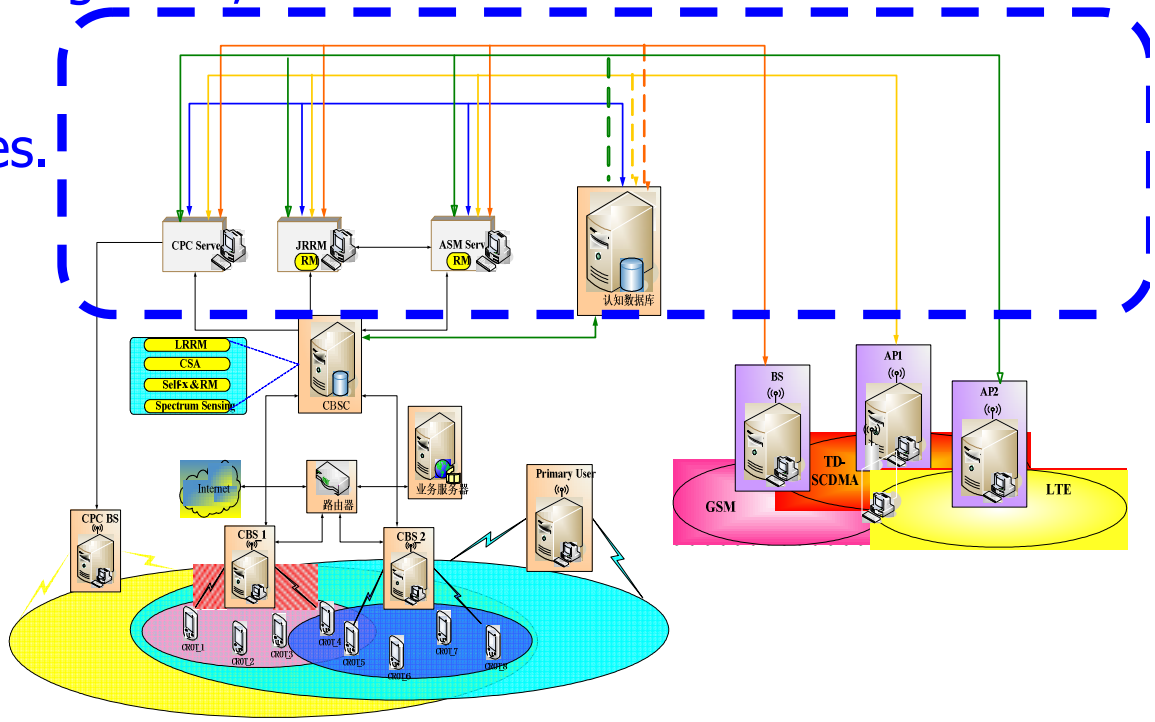
- Platform logical entities-- Part of the network side , including:

the cognitive database for RAT heterogeneous network parameters ;

Support for heterogeneous integration, dynamic spectrum management function entities.

Part of the function entities：

- ✓ JRRM Server
- ✓ ASM Server
- ✓ CPC Subsystem (CPC server)
- ✓ Multi-domain cognition database



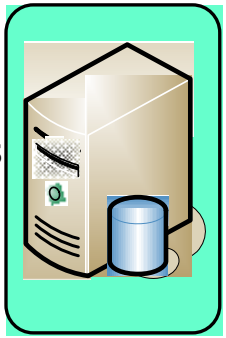
Platform Function Entities Introduction （2）

- **CPC Subsystem**： CPC Subsystem extract coverage information through Heterogeneous network database and support reconfigurable terminals boot network selection by Broadcasting out of CPC-band channel.
  - ✓ Network information collection and maintenance functions ： This function is mainly needed CPC Server with the capabilities of collecting information on network , network maintenance functions of information and periodic updates and calibration of network information.
  - ✓ Network messaging feature ： This function is mainly to broadcast heterogeneous network database network information to end users by CPC channel , enabling users to learn heterogeneous network information 。

CPC 子系统关键组件

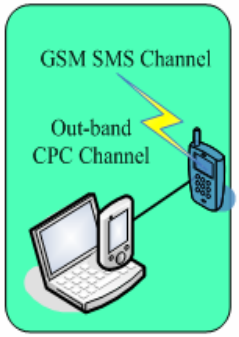
DSNPM collect components, manage Heterogeneous network information , send decisions to CPC Server

DSNPM



Store and manage Heterogeneous network information, divide mesh Grids , according to mesh ID send Information to terminals

CPC Server

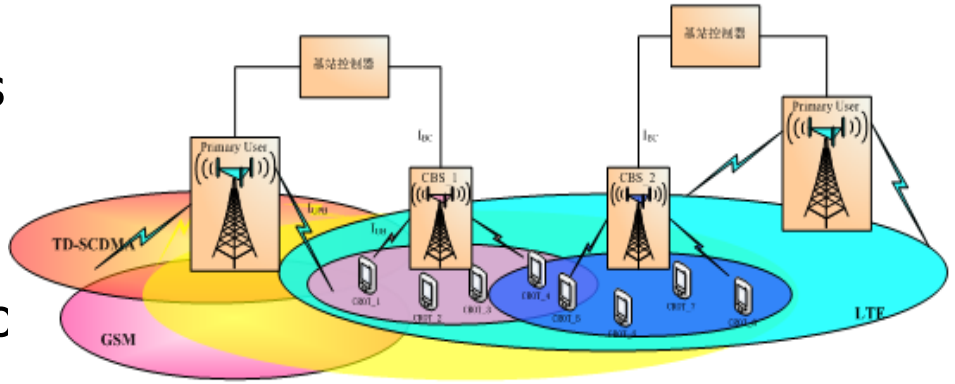


According to the Information form CPC Server, re-configure the Physical terminals to use the appropriate network

Physical Terminal

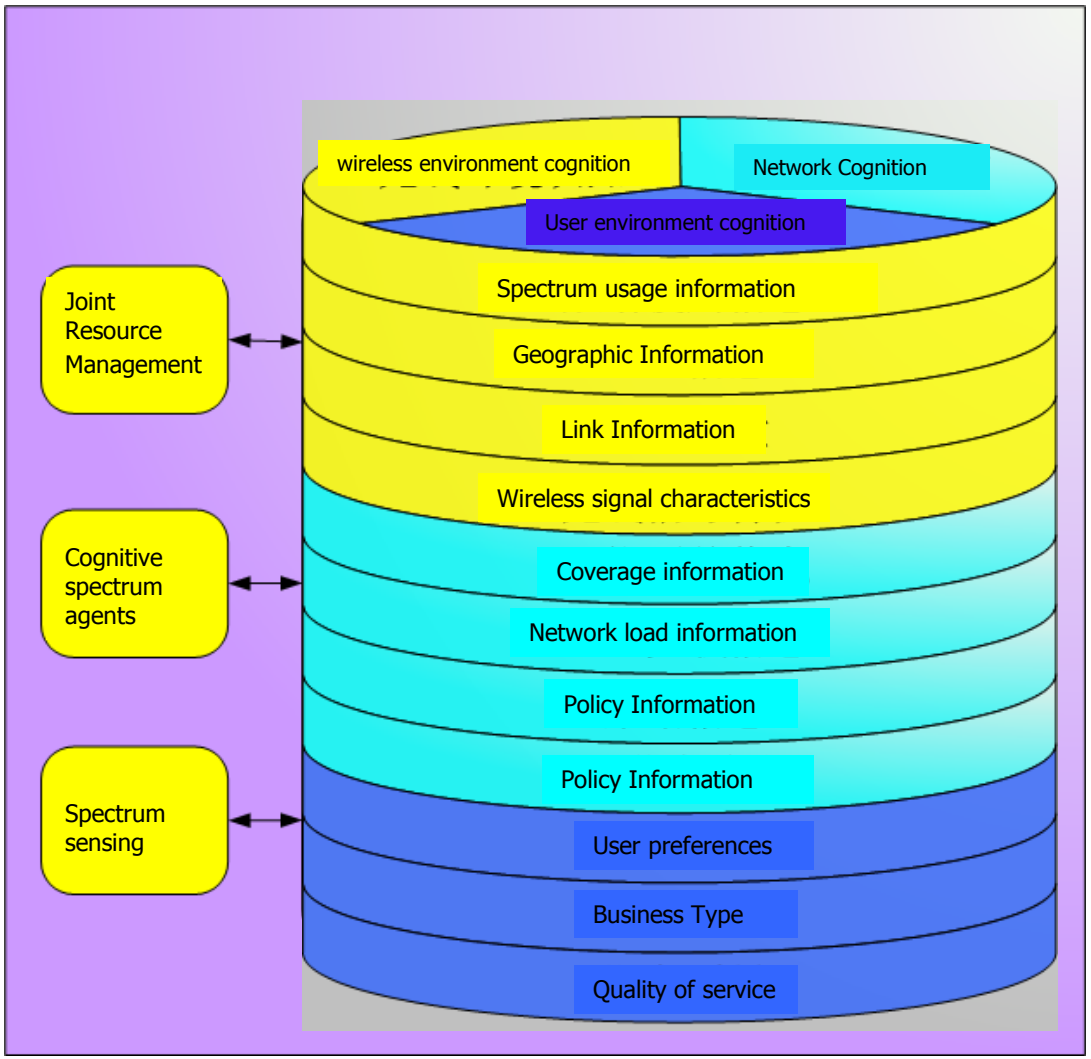
Platform Function Entities Introduction （3）

- Heterogeneous network parameters :
  - The platform system design Multi-domain cognition database\ Network Simulator to collect\manage\heterogeneous network information to generate decisions:
  - ✓ Network Simulator :Network simulator software generates a virtual heterogeneous network environment , expand the platform's Validate and demonstrate the features , Better demonstrate the cognitive characteristics and advantages of wireless networks
  - ◆ The heterogeneous network environment covers the load, heterogeneous network that alsc includes multiple heterogeneous cognitive base station controller and several base stations.



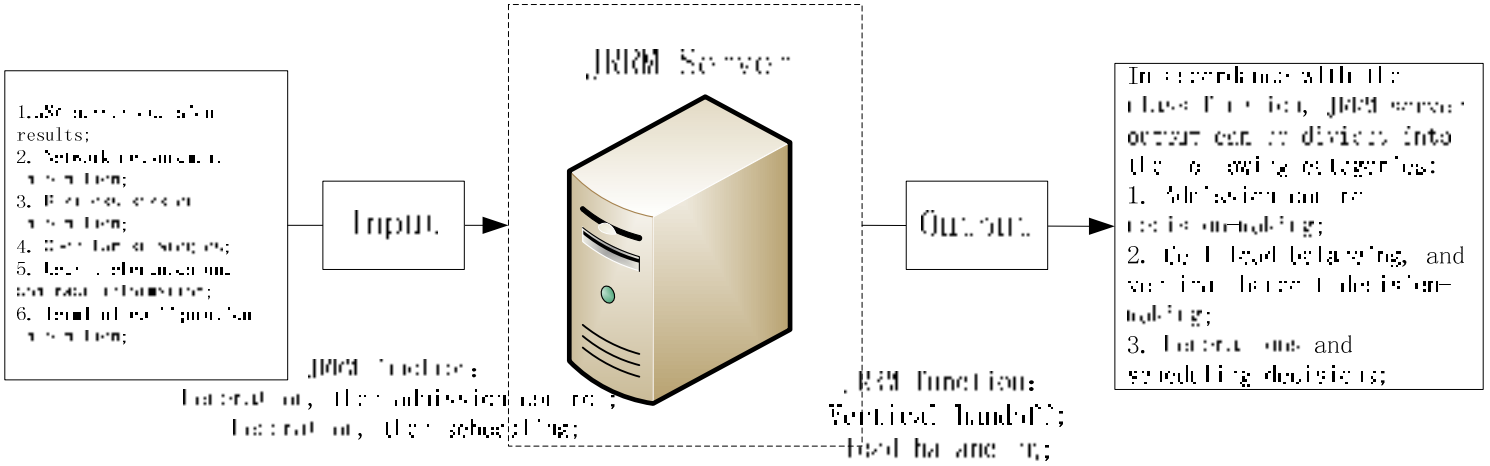
Platform Function Entities Introduction （4）

- Heterogeneous network parameters :
  - ✓ Multi-domain cognition database :
    - used to store and manage the cognitive information generated and used in the cognitive loop.
    - The cognitive information of the cognitive radio System in accordance with their different properties can be divided into different categories:
      - Wireless environment Domain
      - Network Domain
      - User environment domain



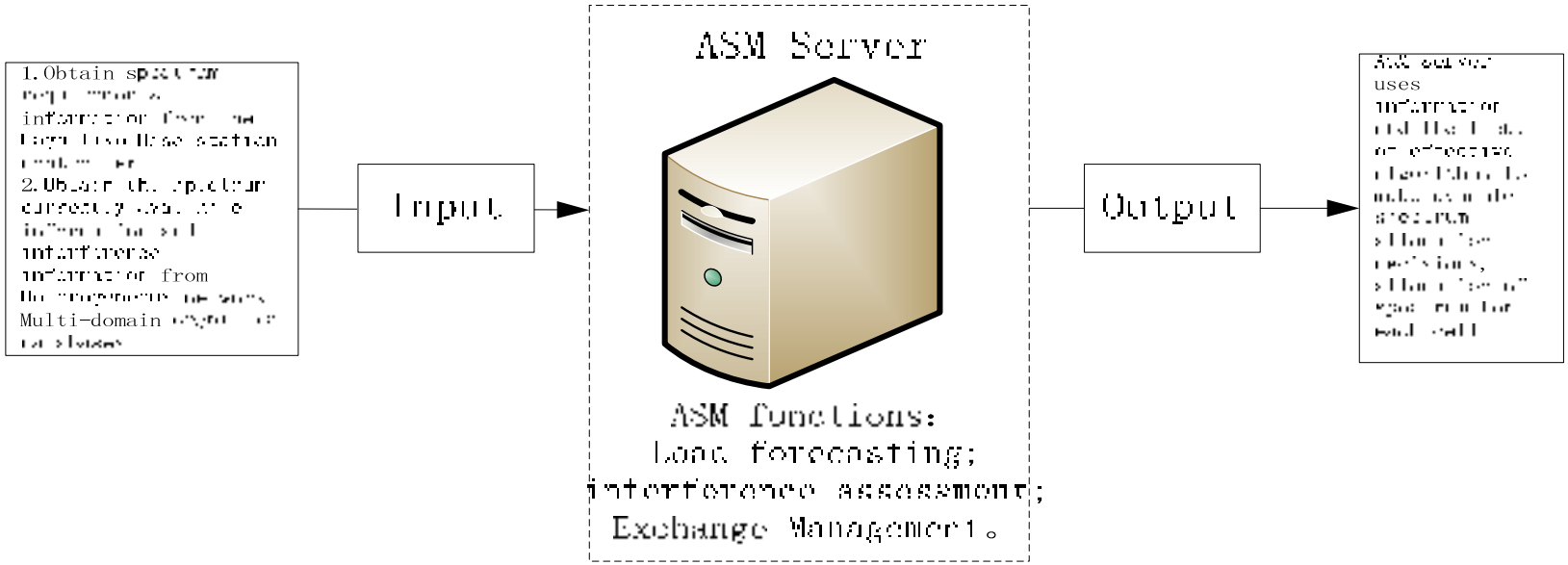
Platform Function Entities Introduction (5)

- Spectrum Management Unit :Upper Spectrum Management Unit contains JRRM Server\ASM Server
- JRRM Server:
  - Satisfy QoS of all the users , and make full use of wireless resources of different networks
  - Improve the utilization of network resources



Platform Function Entities Introduction （6）

- Spectrum Management Unit ：
- ASM Server：
  - dynamic spectrum allocation between communities of heterogeneous networks , to the purpose of efficient use of spectrum



Significance of TD-LTE-Advanced Oriented CWN Demo System

- 2.3-2.4GHz is one of the working bands suggested by the IMT-Advanced System , also the targeted working band of TD—LTE. The platform aims to address the IMT-Advanced system, the dynamic utilization of the spectrum ;
- Solve the coexistence of IMT-Advanced systems and radar systems ;
- Realize convergence of heterogeneous wireless networks, solve the interoperability issues of multi-radio access network

Thank You for Your Attention!

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