A Reconfiguration Trial on the Platform of Allied Information for Wireless Converged Networks

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***Abstract*—Platform of Allied Information (PAI) promotes persistent innovation and application of the wireless technologies among different institutes, based on an open, safe and controllable network architecture. The platform architecture, unified interface, security mechanism, and reconfiguration are designed to achieve the convergence of various wireless experimental resources. In this paper, the reconfiguration mechanism is designed and a reconfiguration trial is implemented based on the Platform of Allied Information, to verify the ability of integrating experimental resources in the related units.**

Keywords-wireless communication; reconfiguration; convergence; PAI.

I. Introduction

In recent years, wireless communications have had a rapid development with the emerging of new wireless technologies, including cognitive radio [1], network coding [2], cooperation and coordinated transmission [3][4], self organizing network [5], and so on. But, most of them are still in the stage of theoretical research or small-scale validation without large-scale trials verified which restricts their further development. At the same time, wireless experimental resources in different forms, such as the wireless devices, simulation environment, experimental instruments, software modules, scatter in different places with the lack of unified usage. In order to meet the needs of resource sharing, these different resources should be integrated to work for the innovation and application research of wireless technology. Thus, with the support of national Science and Technology major project, Tsinghua University initiates and constructs an environment, named Platform of Allied Information, as shown in Fig. 1, for development and verification of various new wireless technology and new services with related universities and companies.

One of the basic tasks of PAI is to build an open, safe and controllable transmission platform. With PAI, the cross-region and inter-unit remote collaborative researches and developments of wireless technology can be achieved, and the distributed experimental resources can be fully integrated and utilized for experimental verifications researches of new wireless technology and new services by more than one allied unit.

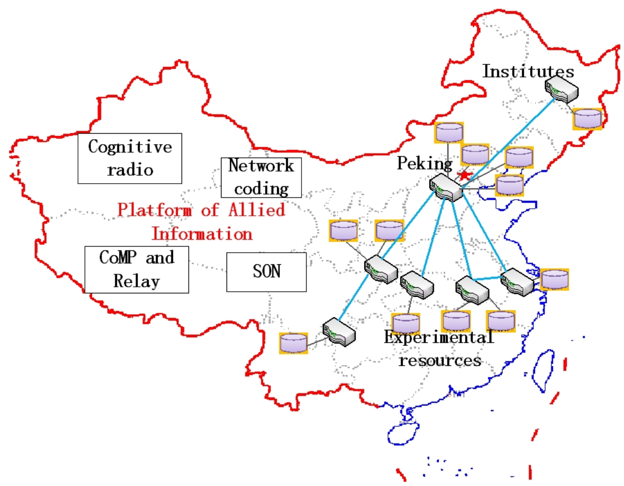

Figure 1. Resources sharing and collaborative development of PAI.

In this paper, the reconfiguration mechanism is designed and a reconfiguration trial is implemented based on PAI. Through appropriate resource configuration and experiment configuration, wireless innovative experiment could be tested to prove the feasibility of the proposed reconfiguration mechanism.

The rest of this paper is organized as follows. We will introduce the major problems solved by PAI in Section II, and then describe the design and implementation of PAI in Section III. In Section IV, the reconfiguration mechanism is described. In Section V, we show the running of real-time reconfiguration, then give a conclusion in the last section.

II. Major Problems Solved by PAI

Considering the extensive flexibility, the open platform architecture is adopted. We use the China Education and Research NETwork (CERNET) [6] as the wired transmission backbone as well as dedicated gateway devices and unified local interface as the access of the various experimental resources. To ensure real-time control with high-speed data transmission, there will be separate paths for data and control signal. Resource management, user management, experiment operation and other aspects are in-depth considered and optimally designed.

A. Unifying Specifications of the Interface

The specifications of the interface between the platform and experimental resources are clearly defined. A scalable universal interface is designed to support the access of various wireless devices, simulation environments, experimental instruments, and software modules. Some typical experimental resources are given as follows.

- Wireless devices, such as Universal Software Radio Peripheral (USRP) [7], WARP [8].
- Simulation environments, such as simulation platforms based on MATLAB, OPNET and NS2.
- Experimental instruments, such as signal generators, spectrum analyzers, and channel simulators that are available to Internet.
- Software modules, such as software developed by OSSIE [9] and GNU Radio [10].

B. Centralizing the Scheduling and Management

Since the experimental resources are highly distributed, the unified management mechanism should be studied and developed to support different experimental resources, end-users and experimental procedures. A centralized management system is established to achieve the following functions.

- Convert the end-users' instructions into local or remote operations.
- Manage the data exchange between different experimental resources.
- Submit results to end-users.

C. Improving the Security Mechanisms

The security mechanism is designed to ensure safety during the access of hardware and software and implementation of experimental verification. The communications procedures are completed by a collaboration of the hardware and software modules, the security of the verification platform aim at software security and hardware security.

D. Keeping the Compatibility

The new wireless technologies are emerging continuously. The high requirements for the verification platform should be satisfied, such as rate matching, adaptive access and experimental approach selection. The core factors, parameters and experimental needs of the mainstream wireless technologies at present are analyzed and summarized. The basic interface specifications, operating procedures guidelines and feasibility assessment methods are established to ensure regular development of the experiments.

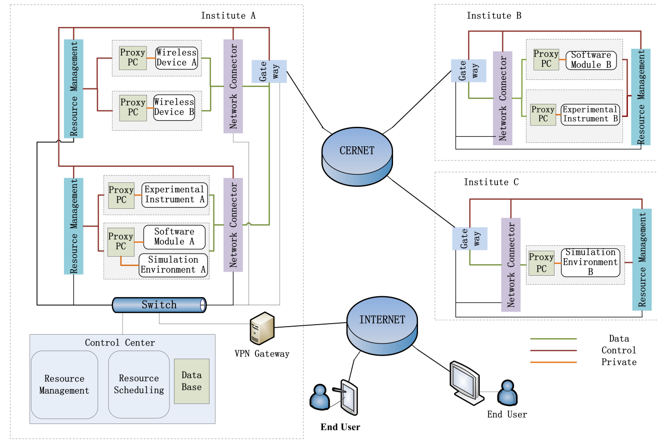

Figure 2. Basic architecture of PAI.

E. Building the Experimental Resources Library

The experimental resources library is built with a variety of commonly used hardware devices, unit components, software modules, simulation functions, and system components combined with the hardware and software. New components developed by different users must meet certain specifications before adding to the library. They must go through self testing, system testing and multi-parameter testing, to ensure proper functioning.

F. Brief Summary

In order to construct the platform, the major problems mentioned above should be addressed based on the technology accumulation of the cooperative institutes. Because this paper focuses on the scheduling and reconfiguration of wireless communication system, the interface, security and library technologies would not be described in detail.

III. Design and Implementation of PAI

A. Basic Architecture

PAI consists of four major parts: Experimental Resources, End-Users, Control Center, and Backbone Networks, as shown in Fig. 2.

All accessed Experimental Resources need to be reprogrammed in accordance with the unified interface specifications. End-Users are the operators of the experiments. The Control Center works with reconfiguration mechanism to configure and manage all Experimental Resources; it provides further management functions such as authentication and security management. Backbone networks is the basis of the entire platform, using special network equipments to provide a high-speed, stable and secure network access.

B. Interface Specifications

Interface specifications guide the Experimental Resources transforming the private Application Program Interface (API) into the public interface with the help of Web services.

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Special access mechanism such as manually upload data by End-User would be provided for the Experimental Resources without suitable interface adaptation. Some typical Experimental Resources are adapted as follows.

- USRP is a widely used software defined radio test bed, which provides RF, ADC/DAC and IF and customizes the baseband processes. USRP is connected to the proxy PC via the USB port; GNU Radio provides a major modules library to operate USRP peripheral devices. The common features are not difficult to show through the Web service like the basic file send / receive applications.
- MATLAB is the most popular simulation tool; many institutes have accumulated lots of MATLAB wireless communications simulation environments for many years, which could be released to authorized end-users through Web services. MATLAB demonstrations could be adapted by the MATLAB engine. MATLAB engine is a stand-alone C / C++ program, which can call the MATLAB functions through COM objects, send commands to the MATLAB process, transmit parameters and receive results.
- The interfaces of Agilent instruments are GPIO, USB, LAN, etc. A proxy PC is established to operate the instrument through an adaptive process that is developed based on the Agilent VISA and SICL libraries. The proxy PC needs to send the parameters assigned to the reserved instrument, and capture the measurement report.

C. *Configuration and Management*

The Control Center showed in Fig. 3 allows End-Users to reserve the Experimental Resources with permission, after that various services provided by the Experimental Resources could be called. Some experiments are carried out with the interconnection of the data from different Experimental Resources; others are carried out with the cooperation of several End-Users. The experiments could be operated not only by remote end-user but also at the appropriate given time.

IV. RECONFIGURATION MECHANISM

Reconfiguration can be realized by software reconfiguration, research of software reconfiguration is embodied in software architecture description language and its support system [11]. Related methods are software reconfiguration based on mapping rules, software reconfiguration based on hierarchical message bus architecture [12], software reconfiguration based on the C2 style software architecture [13], etc. These software reconfiguration mechanisms separate the whole software system into modules, and architecture description language is used to describe the connection between modules and connectors. The modeled software system increases system flexibility, so the system became enabled to refresh in order to meet new environments and demands [14].

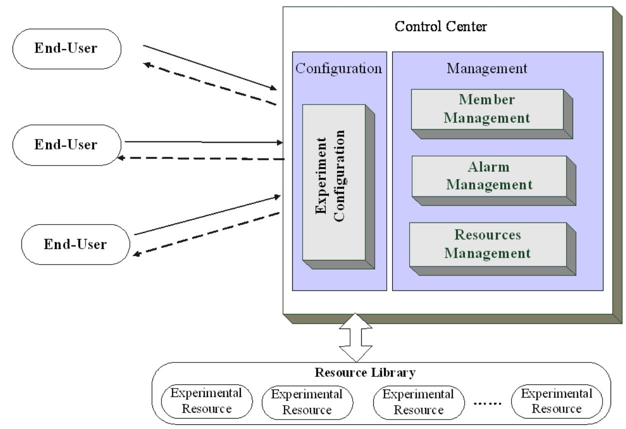

Figure 3. Centralized configuration and management of the Control Center.

With the development of network, the reconfiguration mechanisms discussed above are not suited to the complex distribution environment and flexible application model. This paper extends the application of reconfiguration mechanism into the real converged network environment, giving a method of reconfiguration on PAI. With the proposed reconfiguration mechanism, PAI can be configured into appropriate applications according to different experimental needs.

The reconfiguration mechanism is realized by Resource Management and Experiment Configuration module in Control Center. Resource Management mainly solve the issue of ”resources’accessibility”, while the Experiment Configuration is mainly responsible for the scheduling of resources and interaction between resources. Through appropriate Resource Management and Experiment Configuration multiple wireless innovations have integrated effectively, which promotes the loach of wireless innovative experiment.

A. *Resource Management*

Resource Management starts from resource certification. In PAI, resources with a characteristic of wide distribution are belong to different network nodes and connected through the CERNET. These resources can be specific equipment, software modules, virtual instruments, etc. They are highly heterogeneous; typically do not have a unified interface to the configuration and management module. So the prime problem to be solved is how to promote the sharing of resources, providing a unified standard for resource description.

Web services [15] were defined as the abstract form of accessed resources and unified XML resource description format as a resource certification and identification rule. Through the adaptation, the private interface is released into the public way for the Resources Management module API

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<table>
<tr><td colspan="2">Msg_length
(4B)</td><td colspan="3">Des_add
(6B)</td></tr>
<tr><td colspan="2">Src_add
(6B)</td><td>Trans
(1B)</td><td>Mark
(1B)</td><td>Command
(2B)</td></tr>
<tr><td colspan="5">Data (scalable)</td></tr>
</table>

Figure 4. Resource commnication packet format.

calls. XML description files include some basic properties and operation commands of resource, such as resource name, functional description, the command name, command description, the command parameters, return values and so on.

In PAI, the main function of Resource Management is carried out by the Resource Management module, in which the XML file was analyzed to get related information, identify resource function, and then provide users with the ability of operating resources.

B. Experiment Configuration

Experiment Configuration schedules experiments and ensures the interaction between resources, which are completed by the cooperation of Experiment Scheduling and Resource Communication sub-module.

Experiment scheduling sub-module is responsible for the initial configuration. When users log in, they can create a project on demand visually, finishing resources selection, topological link, command parameters configuration and other configuration operations. The initial configuration information is programmed by Experiment Scheduling sub-module and saved to the database for rechecking.

Resource Communication sub-module defines the communication protocol between resources. It completes the data interaction between resources and realizes the mapping of resources to the actual function based on the initial configuration information. The protocol format is shown in fig.4. *Msg_length* specifies the length of the entire packet, 4Byte; *Des_add* and *Src_add* show the destination and source address of the packet, each 6Byte; *Trans* identifies the process of communication between resources, starting from 0, 1 to end, 1Byte; *Mark* identifies whether the packet has segments, 0 for no segment, others for the sequence number of the segments, 1Byte; *Command* is used to store a specific order of resources, 2Byte; *Data* holds the data associated command; its length is variable according to the corresponding order. A larger amount of data can be transmitted by serial segments.

V. Running of Real-time Reconfiguration

In this section, a trial is given to test the reconfiguration mechanism. As shown in Fig. 5, this experiment includes two sets of USRP equipments (tagged as USRP1, USRP2),

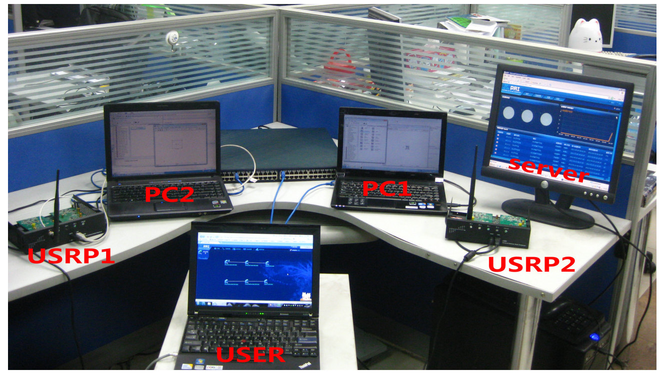

Figure 5. Scene graph of the reconfiguration trial.

```
<?xml version="1.0" encoding="GBK" ?>
- <Device> -
<Name> USRP1 </Name>
<IP> 166.xxx.xxx.233 </IP>
<Description> USRP device that can send or receive </ Description>
<Address> Tsinghua x-xxx </Address>
<AccessType name=" WebService ">
<Port> 8080 </Port>
</AccessType> </ AccessType>
- <Commands>
- <Command>
<Name> send </Name>
<Description>Send a text using USRP </ Description>
<Order> send.sh </Order>
<Parameters>
<Parameter Type=" String "name=" --bitrate" description=" sending rate "default=" 100k" />
<Parameter Type=" Float "name=" --tx-gain" description=" sending gain "default=" 45 "/>
<Parameter Type=" String "name=" --freq" description=" RF frequency "default=" 2.4G" />
</Parameters>
</Command>
- <Command>
<Name> send check </Name>
<Description> Send a text using USRP  </ Description>
<Order> send_check.sh </Order>
<Return Type=" String "name=" result" description=" sending progress "/>
</Command>
</Commands>
</Device>
```

Figure 6. USRP1 XML description file.

convolution coding module and Viterbi decoding module (deployed in PC1), source coding and decoding modules (deployed in PC2). All resources are deployed in network and connected by special equipments. Through USER PC, users get access to the Control Center (server) to configure the whole experiment.

All the related resources access to PAI need to be reconfigured as defined in section IV, using Web services as a public API to the Control Center and loading XML files to describe the information of the resources. Take USRP1 as an example, the XML description file is shown in Fig. 6. In this case, the reconfigured parameters includes transmission rate, transmit power gain and RF frequency.

Resource Management module verifies the legitimacy of XML documents, and parses out the relevant information,

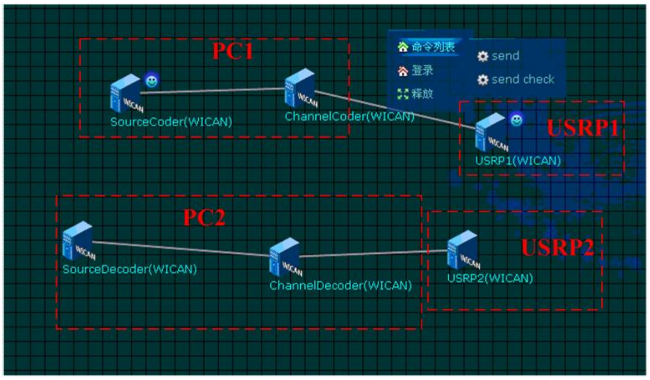

Figure 7. Initial configuration interface.

then feedback a list of commands. When users log in, select the relevant experiment resources, render the link topology, and configure the appropriate experimental parameters, as shown in Fig. 7. We place the SourceCoder and ChannelCoder modules in PC1 and send the coded bitstream to USRP1, convert it to radio frequency and then transmit, through the airinterface, USRP2 receive the radio frequency signal and convert it to baseband signal, the baseband signal is transported to PC2 and be processed with the ChannelDecoder and SourceDecoder modules to get the original bitstream.

After the initial configuration is completed, Experiment Scheduling sub-module generates configuration file according to the operations above and save it to the database. Resource Communication sub-module follows the communication protocol defined in Section IV to package the data. Experimental data transmits via source coding and convolution coding module to USRP1, where GMSK modulation and digital up conversion are completed, and then the experimental data are transmitted. Correspondingly, in the USRP2, data is received and digital down conversion and demodulation will be done, the processed data will be passed on to Viterbi channel decoding module and the source decoding module to reconstruct the source data. The reconstructive data as well as the source data is passed back to the USER. All the input/output data streams mentioned above are retransmitted by the Control Center; thus all the intermediate results can be collected and observed.

VI. Conclusion

We have designed and developed PAI to meet the convergence of various innovative wireless technologies. A novel method of reconfiguration has been proposed and a reconfiguration trial of wireless transmission has been done based on the overall configurability of PAI. The distributed Experimental Resources in related research units can be fully integrated and utilized for experimental verification of new wireless technologies, such as cognitive radio, network coding, cooperation and coordinated transmission, self organizing network and so on. PAI supports the research for future broadband wireless technology effectively. More work about security and user interface of PAI could be in-depth studied to improve the safety and applied range.

VII. Acknowledgment

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