ARCHITECTURE AND CERTIFICATION METHODS FOR COMMON PILOT CHANNEL

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Abstract— **Cognitive Pilot Channel or Common Pilot Channel (CPC) is essential in particular for cognitive/reconfigurable radios that support concepts such as flexible spectrum management, dynamic spectrum allocations. It simplifies and speeds up the scanning process for reconfigurable terminals that are not aware of the concurrent spectrum constellation. However management system architecture for Common Pilot Channel (CPC) is required for efficiently managing the CPC information and efficient utilization of resources with reduced signalling overhead. More over, the information provided by CPC has to be correct and up-to-date so that the relying MS can verify its origin and integrity to make the right decision. In this paper we introduce a certification procedure for CPC.**

Index terms-- **reconfigurability, CMS, fast scanning, advanced spectrum management, CPC**

I. INTRODUCTION

Cognitive Pilot Channel or Common Pilot Channel (CPC) is essential in particular for cognitive/reconfigurable radios that support concepts such as flexible spectrum management, dynamic spectrum allocations [1]. A huge number of different radio communication systems exist, changing over time and depending on location. It would be impractical and time consuming for a reconfigurable radio device to scan the whole radio spectrum for available radio systems. It is necessary to provide prior network information to simplify and speed up the scanning process.

In [2] a solution for the scanning process is given that can be implemented through a hierarchical country-wide common pilot channel. For each RAT, a broadcasting channel (BCCH) with corresponding coverage is assigned. An operator may use the same RAT or several RATs in different frequency bands to best suit users' demand, whereas the spectrum allocation can be dynamically changed. A country/region may generally have several operators; the country level information may vary even inside a country. In this paper we define management system architecture for Common Pilot Channel (CPC). The CPC management system (CMS) is composed of CPC transmission station (CTX), Base Station (BS), at Mobile Station (MS)

with a reconfigurable radio, see Figure 1. The advantages of the management CPC architecture are:

– Open system for efficiently managing the CPC information, including dynamic and efficient management procedure, and the certification process for in-time CPC context delivery
– Filtering / prioritisation of announced information

The paper is organized as follows: in chapter II the structure of the common pilot channel (CPC) management architecture detailing deployment scenarios and management function is illustrated. The certification procedures and CPC updating methods is given in chapter III. Conclusions and discussions are given in chapter IV.

II. STRUCTURE OF THE CPC MANAGEMNET ARCHITECTURE

A CPC management system is composed of:

– CPC management station (CMS),
– CPC transmission station (CTX)
– Base station (BS),
– Mobile station (MS) with a reconfigurable radio.

The information sent over the CPC is determined by the CMS and transmitted via CTX. The information describes the communication systems provided by available base stations and the radio communication (configuration) air interfaces employed by them. The CPC information is received by MS to select a RAT to use, and configure its radio for this RAT following the announced CPC information.

The information announced over the CPC may include: Frequency, location, time, RAT description: modulation, frequency, power, etc. To reduce the redundancy transmitted over the air, the information can be coded, e.g., power value can be possibly realised in the form of delta to base standard. Optionally, it also can be that reconfiguration software and configuration description are provided over the CPC.

A. *Deployment Scenarios for CPC management Architecture*

The CPC management system can be deployed in different variants depending on the business models, and related to the origin of the CPC information is collected and provided, for example:

– In the case of the known three-level hierarchical CPC (country-level CPC, operator-level CPC, RAT broadcast), the CPC management system is operated by the operator-level CPC.

– CPC system operated by an independent CPC operator who collects and provides information independently of network operators i.e. an application service provider collects information about networks used by his subscribers. When the information is collected from mobile users, no involvement of network operators is required, or the information provided by the users is utilized to enhance the network-operator-provided information with the experience of users e.g. which RATs/networks work well, which ones are really available. The CMS may have two types of subscription/contractual agreement: One is with the network operators; one is with the end users. Agreement with operators defines what information is announced concerning the operator's networks, and potential payment to the CPC operator. Agreement/subscription with end users defines what information is provided to the end user. The provided CPC information may be freely available to all users, or it may be cryptographically protected (encrypted) so that only users with required decryption key can access the information. So the CPC can e.g. announce basic information for free and premium information (with higher accuracy, with more information, e.g. concerning price) to paying CPC subscribers. When the operator plays as a CPC operator, there is of course no contract between the CPC operator and the operator is needed.

– CPC information provided by home network operator (no global view, but an operator provides information to his subscribers) using information reported by his subscribers (no cooperation with visited network operator to provide information).

CPC information may be provided over a separate CPC radio system, or it may be transported over available network access technologies, e.g. by downloading from an HTTP server through fixed network and stored on the mobile device. The latter case may be relevant in particular if some connectivity exists already or in the recent past as then the user knows from this information what communication systems are available also if no separate CPC system is available (it would require some enhancements on top of the running system, e.g. assigned spectrum out of the band of the operated radio system).

Home network operator may use the information reported by user experienced in different visited networks. Users (software agent installed at the MS) send "*satisfaction reports*" to their home network operator, indication user network, used services (e.g. VoIP, Internet), additional information (time, location, network monitoring information obtained by device) and a quality parameter (could just indicate whether available resources were sufficient, or detailed information like packet loss rate, signal strength, bit error rate, etc.). The home network operator compiles this information provided by several users (his subscribers) and provides it in compiled from as basis for network selection / handover.

B. *CPC Management Functions*

The CMS has the following functions:

CPC Information Filtering

In this function the relevant information of the available radio systems will be filtered such that a MS can start communication with at least one RAT. Advantages reside in the fact that complete information will not be announced over CPC, only information that is sufficient to start a basic or initial communication. More detailed information can then be obtained via regular communication, which is not necessary to be announced over the CPC.

CPC Information Prioritisation

Here information has to be repeated over time but with different frequency according to the priority setting.

High Priority information will be sent more often in CPC i.e. high priority information is repeated within shorter intervals than low priority information.

Priority is settled according to:

– Agreements (payment) of radio system provider e.g. operator who pays more is announced more often

– Basic services supported by many devices allowing to start with some communication early;

specific information useful only for a small number of devices is repeated less often
- "Interaction level" – radio systems used by end users in contrast to those used for machine communication; a human user does not want to wait for some minutes before being connected; but if the user is e.g. a vending machine, this would be no problem
- Utilization: announce RATs with free resources more often than those that are already highly utilized.
- Spectrum scarcity and access rights: information for more expensive spectrum resources are set with higher priority

C. Three level CMS

Several CMSs may exist that exchange information among themselves. The logical connectivity of the three level CMS is shown in Figure 3. The CTX is connected with a number of CMSs. The CMS owners have an agreement with the provider of the CPC system to use the offered CPC service. The CTX is responsible for emitting the CPC information. It provides its own physical device transmitting the country level CPC. CTX can forward the logic information to the selected base stations of cellular network or digital video broadcasting (DVB) network nodes in order to transmit the filtered information.

III. CERTIFICATION PROCEDURE OF CPC

The information provided by CPC has to be correct and up-to-date so that the relying MS can make the right decision. For this purpose, the CPC operator can obtain a digital certificate (e.g. according to X.509v3 format). Operators only issue certificates to those qualified operators who are able to deliver CPC content in time. Besides stating the CPC operator's identity, additional information describing the quality of provided information can be certified. Examples are:
- Test house such as ISO9000 certification that the CPC operator follows and commonly accepted.
- Service-level properties, such as:
  - o Asserted reaction time i.e. maximum delay of the new updated information availability after RAT configuration
  - o Types of RATs will be announced, a certain CPC operator might be providing only information about commercial wireless systems, but not about public safety and professional radio systems
  - o Provided regions information

- o Other information such as network load, pricing information, roaming agreements, etc...

Those sets of information allow the MS receive CPC information to assess the trustworthiness of the provided information and handle the information appropriately.

The public key certified by the certificate can be used directly by the CPC operator to digitally sign the announced information. Other known security technologies for broadcast/multicast systems can be used as well, e.g. 3GPP MBMS security [5].

Operators observe the end user's behaviour through the communication procedure. E.g., as Figure 2 shows, the UE reports to its operator the CPC operator's ID. In case the UE makes wrong reconfiguration due to the wrong CPC indication, the operator can identify this failure.

A. CPC updating Methods

Wireless clients monitor their radio environment for available radio systems; compare with information announced by CPC; in case of deviation (addition of radio system not yet sensed; disappearing of announced RAT) a monitoring report will be sent to CMS. CMS will update the information after checking the differences between actual and announced information thus insuring that accurate information of CPC is always available.

Users may send their report to a central CMS, or they send it to their operator, who then forwards the information (in raw or processed form) to the central CMS.

When actually using a RAT, clients can also report associated measurements to the CMS (e.g. utilization, delays, throughput, bit error rate; packet loss rate). Operators will consider often their internal network information (utilization, free/total capacity) as business-confidential, and will not be willing to share it with competitors. Therefore, a network operator will not have complete information about the best target network for his subscribers. With reports from users about what RATs they found and what services they provided and how well, they can anyhow obtain some indication of the quality of available RATs.

The CMS can announce meta-information describing what information it intends to provide. When a client detects a RAT that, according to this Meta information, does not lie within the scope of the CPC, this RAT needs not to be reported to the CMS.

Such filter mechanism can be implemented in a step-wise iterative manner. Once the MS sends

CMS its feedbacks about their evaluation according to the raw information, CPC information can be updated accordingly.

IV. CONCLUSIONS AND DISCUSSIONS

In order to support efficient radio access under a dynamic spectrum allocation scenario, a coordinated management framework holding a common pilot channel funciton is introduced. This solution facilitates dynamic spectrum allocation in multi-levels including inter-operator, inter-operation-MSs, inter licensed and non-licensed spectrum. The addressed management architecture is leading to efficient utilization of resources and reduced signalling overhead with sufficient security protection. With the flexibility of the introduced management architecture new operator subscriber can use the CMS-CTX structure for efficient CPC access/indication; in the self-organising CPC the information is announced when a user has reported the fact to the CMS, not requiring potentially complicated contractual agreements between network operators and CPC operator. Thanks to the on-the-fly self-learning machine introduced by the functionalities, more Up-to-Date information will be hosted by the futre CPC system: When using the self-organising CPC, differences between announced and actual RATs are reported and the information to be announced over CTX can be updated accordingly.

V. REFERENCE

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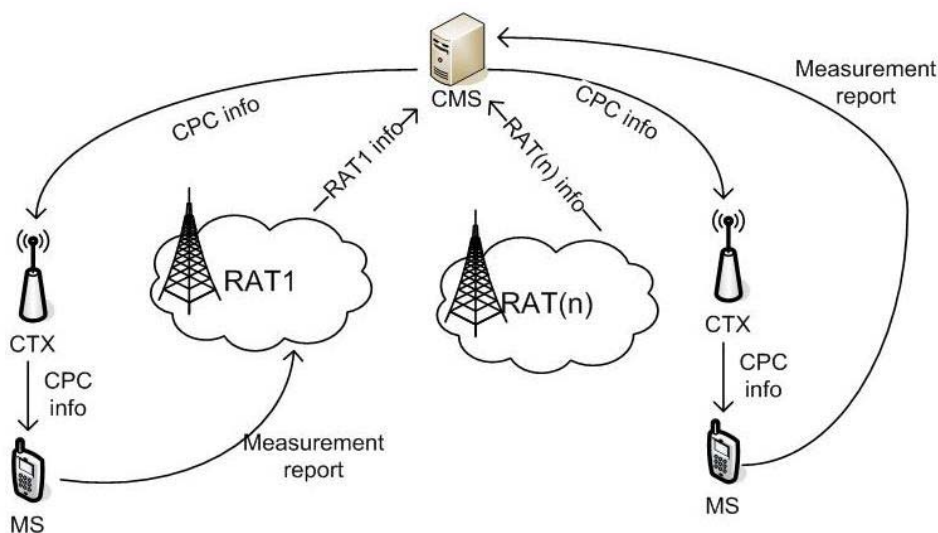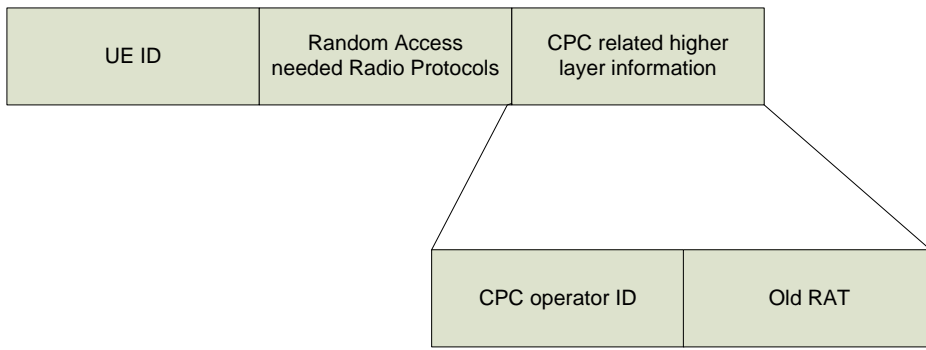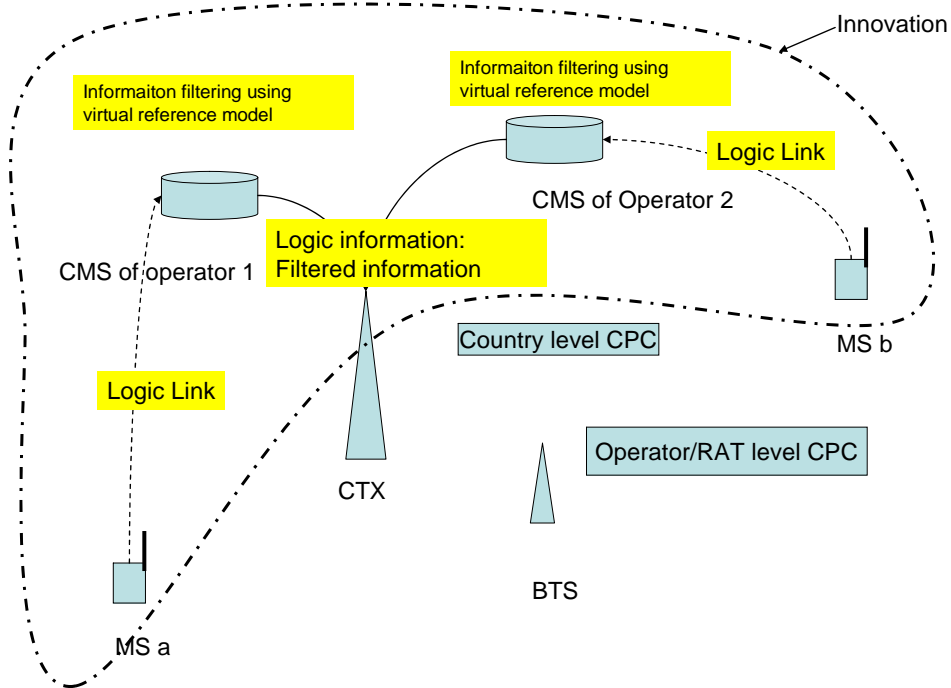[5]   3GPP TS 33.246, 3G Security; Security of Multimedia Broadcast/Multicast Service (MBMS)

Figure 1: Management System Architecture for CPC (CMS)

UE ID	Random Access needed Radio Protocols	CPC related higher layer information

CPC operator ID	Old RAT

Figure 2: Recorded CPC Operator Information

Figure 3: CMS-CTX embedded CPC System