Fundamental research about the space-time information certification using VLBI correlation technique

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We have the plan to develop techniques for validating the position and time information of users who have a high demand on accuracy of these parameters. NICT has already developed the advanced precise positioning service (APPS) and has set up position validation test servers which provide mm accuracy for advanced users. The main target of this research is to generalize this system for the user who does not need high accuracy. In addition, the system will be able to validate not only position information but also time, i.e. 4-D validation. The user terminal which is equipped with a GPS receiver and a digital TV tuner should send GPS position information as well as sampled digital TV carrier signals to a certification center. In the certification center, digital TV carrier signals will be sampled and recorded independently for the purpose to be correlated with the user's data. If a fringe can be detected with the a-priori position information provided by the user, the user's position is correct. In this case, a certification message will be issued to the user. The focus of this research project is set to the development of an eVLBI technique based on digital TV carrier signals.

An application of VLBI correlation technique

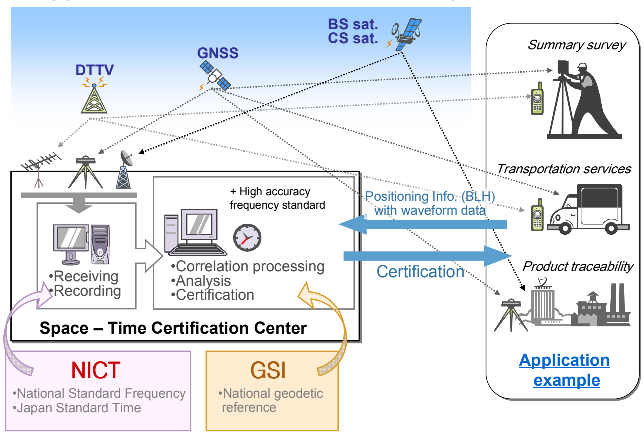

Fig.1 The concept of the space-time information certification system

VLBI can determine the distance and direction of two radio telescopes with mm level accuracy by correlation processing of radio waves from quasars which are received at each telescope. A-priori delay time has to be calculated using the initial position of each telescope before VLBI correlation. The correlation fringe will not be detectable if the initial position is wrong or has larger error exceeding the size of the search window.

In this research project, we are going to apply a similar technology and confirm whether the initial position of user is right or not. Both, the certification center and the user receive radio waves which are emitted from a common transmitter at the same time. The user sends his received data to the center together with the position information that is obtained by other means. **If the user's position is correct, an interference fringe will be detectable by correlation processing, which relies on a-priori delay information calculated from the information sent to the certification center. By this process, it is possible to confirm the user's position and issue a certificate for it.** This certification system is expected to support a large number of users who have different requirements on the position accuracy certification level (Table 1). Thereby, accuracy will range from the meter the level, which is based on a single fringe detection, to millimeter accuracy, which relies on correlation of many different signals such as those emitted from GPS satellites.

accuracy: Low → High

Radio Signal	Certification Level A (m)	Certification Level B (cm)	Certification Level C (mm)
Quasar	○	○	◎
GNSS	○	○	◎
CS,BS	○	△	—
DTTV	○	—	—

Table 1. Certification level and usable radio signal for fringe detection

The users who want to get a space-time certification can select a kind of radio signal depend on certification level from A (meter accuracy) to C (millimeter accuracy). When GNSS is selected, the certification has 4-D validation with high accuracy. When DTTV is selected, it has only 2-D (distance and time) validation with low accuracy.

The procedure of certification

1. Reservation

The user who wants to get a certification must inform the center in advance in order to be prepared to record of the same radio signals at the certification center.

2. Recording at the certification center

The center starts the recording of the radio signals based on the user's request.

3. Recording on the user's terminal and obtaining the position

The user also starts recording of the same radio signals and measures his position. The user's terminal must be synchronized with the standard time in advance.

4. Sending of the data and position information to the center

After recording, the user can send the data to the center. The data size is expected not to exceed a few Mbytes since signals are much stronger than those obtained from quasars and thus require less integration time to achieve high signal to noise ratios.

5. Correlation process at the center

The center correlates the signals provided by the user with those received at the center using the user reported position as a-priori value.

6. Certification of the user's position and time

If the fringe is detected, the center issues a certification to the user.

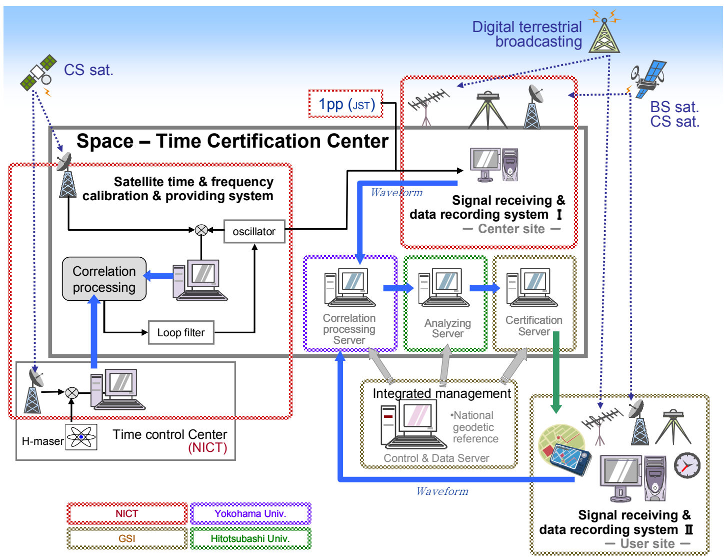

Fig. 2 System detail and development assignment

The schedule and team

Developper	FY 2009	FY 2010	FY 2011	FY 2012
NICT (with private company)	time & frequency standard calibration & providing system development	system integration test	demonstration experiment	product summarizing
GSI	control system certification system development	installing		
Yokohama University	correlator system development	installing	Product & report	
Hitotsubashi University	analyzing system development	installing		

Table2. Research schedule and task assignments

Research term : 4 years (April, 2009 – March 2013)
FY2009: Development
FY2010: System integration
FY2011: Demonstration experiments
FY2012: Product summarizing

Acknowledgment

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