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Virtual Private Connectivity between Class Rooms

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Abstract:

Real-time interactive virtual classroom with tele education experience is an important approach in distance learning. However, most current systems fail to meet new challenges in extensibility and scalability, which mainly lie with three issues. First, open system architecture is required to better support the integration of increasing human-computer interfaces and personal mobile devices in the classroom. Second, the learning system should facilitate opening its interfaces, which will help easy deployment that copes with different circumstances and allows other learning systems to talk to each other. Third, problems emerge on binding existing systems of classrooms together in different places or even different countries such as tackling systems intercommunication and distant intercultural learning in different languages. To address these issues, we build a prototype application called Open Smart Classroom built on our software infrastructure based on the multiagent system architecture using Web Service technology in Smart Space. Besides the evaluation of the extensibility and scalability of the system, an experiment connecting two Open Smart Classrooms deployed in different countries is also undertaken, which demonstrates the influence of these new features on the educational effect. Interesting and optimistic results obtained show a significant research prospect for developing future distant learning systems.

Index Terms:
Pervasive computing, computer uses in education, Web-based services.

I. INTRODUCTION:

Despite the emergence of the new generation of Web based learning systems, traditional learning mode, where teachers and students are face to face with each other in the same classroom continues to have its unrivalled advantages.

Unlike many Web-based learning systems adopting an asynchronized way here, the teacher publishes learning content statically on the Internet and students obtain static learning materials at different times, real classroom learning follows a synchronized learning process, where students in and out of classroom can listen to the live instruction while the teacher gives the lectures. In most cases, synchronized learning catches participants' attention and interest much more effectively than asynchronized one. Therefore, real-time interactive virtual classroom with tele-education experience is of indispensable significance in distance learning.

Further, with the development of pervasive computing aimed at providing natural human-computer interface and multimodality communications, integrating pervasive computing technologies into classrooms enhances the experience of both teacher and students, where the teacher easily interacts with local and remote students while the students are able to give feedback to the teacher. There are many learning systems embedded with these features such as Tsinghua University's Smart Classroom [32], ActiveClass [11], Class Talk [14], Interactive workspace [2], which successfully seek a better teaching and learning mode based on traditional face to face classroom learning. These are called class room based e-learning systems.

1.New Challenges and Requirements:

These classroom-based e-learning systems help both the teacher and students in the learning process and have achieved successful results. However, with the development of pervasive computing, new requirements are raised for the openness of the system, extensibility, and scalability. Three main aspects of this issue are illustrated below in detail. (i) Open Architecture for Integrating Increasing Human-Computer Interfaces and Mobile Devices -With the development of human-computing interaction, more and more natural human-computing interfaces have been integrated into people's daily life to enhance work efficiency. In the learning area, human-computing interface can facilitate the teacher to teach the class and help the students learn and discuss with others. Several projects, such as [2] and [32], implement special human-computing interfaces in their learning environment. At the same time, mobile devices such as mobile phone, smart phone, PDA, and laptop have been easily accessible for ordinary people. Researchers in [9] and [16] emphasize that mobile devices play an important role in learning.

For example, the teacher uses his Smart Phone to bring the presentation file and to control the slideshow, while the students can use a laptop to discuss with others. Some of these features have been incorporated in several projects. For example, Active Class [11] enables the students to use mobile devices to give feedback to the teacher; Smart Classroom [32] and iRoom [2] support many human-computer interfaces and mobile devices joining in and interacting with existing applications and devices. Increasing human-computer interfaces and mobile devices demand their integration in sophisticated system architecture.

The integration should follow a generic way rather than an ad hoc method for each interface and device. The architecture is required to provide general solution and mechanism for integrating or building human-computer interfaces in the learning environment. Also, the architecture needs to provide standard communication interface for mobile devices to join in and interact with other modules, adapting the different systems of mobile devices with minimal prior configuration, such as Linux, Symbian OS, Palm, and Windows CE.

(ii) Open Service-Oriented Channel for Easy Deployment of Different Requirements and for Improving System Capability-How to simplify the deployment of this kind of learning system for different requirements is another challenge. Referring to the idea and achievement of service-oriented architecture [25] in Semantic Web area [26], encapsulating the modules into services and introducing a workflow mechanism into classroom-based learning system is a feasible solution. It requires the system to establish a mechanism for outside workflow designers and management tools to control the service of modules in the system.

Thus, the system needs a service-oriented channel to bridge the inside and outside of the system. This channel not only contributes to the deployment but also helps the learning system to utilize outside dedicated services such as invoking language translation service to facilitate the students' understanding. Moreover, it enables the outside system to invoke the internal services provided by a learning system. For example, the classroom could provide a student attendance service by which the mobile company could dynamically find out whether the student attends Class A and send that information to the administrators.

(iii) Open Network in Which Different Classrooms Bind with Each Other- The third challenge is to support multiple classrooms to connect with each other and have classes together over intercontinental WAN. With the increasing requirements of intercultural and intercontinental communication for learning purpose, just enabling remote students to participate in the Smart Classroom and to easily communicate with teacher and local students is inadequate. Therefore, allowing two or more real-time interactive classrooms to connect with each other is one of the aims of building future distance learning systems. To connect these classrooms, we need to tackle the intercommunication problem in the open network, including video, voice, and controlling messages.

Besides, we need to address interclassroom human-computer interfaces by allowing the local human-computer interface to be used in binding classrooms as well. Moreover, because of the inevitable differences among these connected classrooms, necessary transformation mechanism is needed. For example, the classroom at Kyoto University may use Japanese, while the one at Tsinghua University may use Chinese. Simply connecting these two classrooms it will cause a misunderstanding because of the differences in languages. Therefore, a robust translation service and other involved mechanism for intercultural communication should be utilized to make the people in these classrooms understood. Additionally, because of the differences in understanding the effectiveness between participants in one classroom and those in other classrooms, aided tools for enhancng the communication and understanding, such as discussion and feedback, are also necessary to these connected classrooms.

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This simultaneously synchronous intercultural teaching mode that permits multiple classrooms in different places with different nationality students to behave as one class together has long-term significance for the research of intercultural learning and communication.

2. Our Approach:

Addressing the three challenges mentioned above, we present a prototype system called Open Smart Classroom. Open Smart Classroom is a open classroom-based e-learning system, based on the Smart Classroom at Tsinghua University [32]. More extensibility and more scalability is demonstrated in Open Smart Classroom. We built two Open Smart Classrooms, one is at Tsinghua University and another is at Kyoto University (as in Fig. 1). The classroom of Tsinghua is a 6.5 _ 5.5- meter room, which has four wall-size projector screens, two on the front wall and two on the side wall. The classroom at Kyoto University is a 10.0 _ 3.0-meter room, which has three LCD screens. Several natural human-computer interfaces are integrated in Tsinghua's classroom, e.g., touch-sensitive SmartBoard. Connected by open internet, two classrooms and multiple software modules in them provide the classroom functionality.

All software modules run on our software infrastructure, called Open Smart Platform, to communicate and coordinate with each other. Open Smart Platform is designed as a generic software infrastructure for Smart Space [13], which has been regarded as a testbed for research in pervasive computing area. As a learning environment integrated by pervasive computing technologies, the classroom-based e-learning system could be considered as a Smart Space, which benefits the existing solutions of Smart Space. In addition, the extensibility and scalability of classroom-based e-learning system correspond to the openness requirements for Smart Space. Thus, Open Smart Platform is not only to build Open Smart Classroom but also has important significance in the research of Smart Space, contributing to the research of pervasive computing as well. In this paper, we explore Open Smart Space in Section 2. Section 3 introduces the architecture, new features, and implementation of Open Smart Platform. Section 4 explains the design of Open Smart Classroom. Section 5 indicates the evaluation and user study result. Section 6 presents the related work, and we draw our conclusion in Section 7.

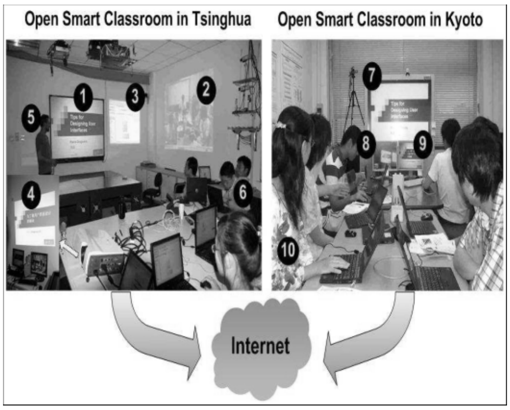

Fig. 1. The Open Smart Classrooms systems

Two classrooms located in Tsinghua and Kyoto, respectively, are connected through open Internet. The live video is shared in both classrooms. The original presentation is in

II. RELATED WORK:

In this paper, we focus on:

1. Existing Learning Systems in Smart Space-

Several projects work on improving the experience of traditional classroom-based learning using Smart Space technologies. Active Class encourages in-class participation using personal wireless devices, where the students give feedback on the class using their own wireless devices. However, it lacks support for mobile devices to control and interact with the classroom and has few natural human computer interaction interfaces to enhance the experience of class. eClass at Georgia Tech is another project with automated capture of live experiences for later access. Similar to the Smart Classroom project at Kyoto University [15], its main study is on capturing the live experiences of the class for further reviewing. Nevertheless, both of the projects only work for single classroom and hardly take into account live-class participation for remote students. iRoom at Stanford [2] explores new possibilities for people to work, discuss, and learn together in technology-rich spaces, which have large displays, wireless, multimodal devices, and English, and translated presentations (in Chinese and Japanese) are showed synchronously in both sides at the same time. 1) Touch-sensitive SmartBoard screen, displaying presentation of the class. 2) Live video of Kyoto.

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3) Aided tools helping the students to communicate with each other in different languages and also giving feedback and questions to the teacher. 4) Online Chinese translated presentation. 5) The teacher, giving a class in Tsinghua. 6) The Chinese students using aided tools for discussion. 7) Presentation of the class. 8) Live video of Tsinghua University. 9) Online Japanese translated presentation. 10) The Japanese students, using the aided tools for discussion.

seamless mobile appliance integration. However, iRoom does not consider remote students' interaction either. Smart Classroom at Tsinghua University [32] is similar to iRoom but supports remote students' interaction and communication. It, however, lacks a mobile devices communication mechanism without any preinstalled modules and is limited to utilizing useful services outside of Smart Classroom. All the projects presented above lack support for multiple classrooms working together and hardly involve discussion among students using different languages either.

2. Existing Software Infrastructure of Smart Space-:

There are several developed software infrastructures for Smart Space. Smart Platform [27] developed by Tsinghua University addresses the issues of performance and usability, which has three different communication schemes and loose-coupled multiagent encapsulation architecture. However, Smart Platform does not take the service concept into account and fails to support multiple Smart Platforms communication. Similar to Smart Platform, iRos [2] by Stanford is a meta-OS that ties devices together so that each has its own low-level OS. As the extension of iRos, iCrafter [18] allows users flexibly to interact with the services in the interactive workspaces. Unfortunately, even with iCrafter, the software infrastructure does not consider the issue of multiple Smart Spaces communication. Hyperglue [17], which is a complemental system of Metaglue [3] at MIT, involves the mechanism of resource management for multiple Smart Spaces. Nevertheless, both Hyperglue and Metaglue use Java RMI technology for direct coordination among different modules, which takes greater expenses because of highly dynamic Smart Space. Gaia [12] is a middle infrastructure with resource management and provides user-oriented interfaces for physical spaces populated with network-enabled computing resources. Gaia enables data and applications of users to be abstracted, moved across and mapped to different Smart Spaces. Gaia supports services quite well, however, lacks emphasis on multiple Smart Spaces communication mechanism.

2.Advantages of Service Architecture for Open Smart Classrooms

Using service architecture based on Web Service technology brings out several advantages for Open Smart Classroom.

(i) Workflow:

Workflow based on service architecture in Open Smart Classroom enables the administrator to manage the class more easily. For example, when a new classroom joins in the class, it is very easy to modify the workflow to cope with the different languages used in a new classrooms. When the teacher is giving his class, the administrator and teacher himself can monitor the running status of Prepare-PPTWorkflow to know the number of the translated pages, which helps them to adjust the class when necessary. Workflows also help the developer to build Open Smart Classroom to provide more reusability and customizability; refer to Section 4.3 for details.

(ii) Cooperation of the Services among Classrooms:

The service architecture requires the interfaces of agents in the classroom to be built in a standard way and thus can be reused as the service resource by other classrooms. For instance, the services that translating the PPT files into the required languages provided by PPTControllerAgent can also be used by other classrooms to translate other PPT files as needed. Another example is the decision engine of Smart Cameraman [32], which uses observed context of the Smart Classroom as the input to give the appropriate view of the class as the result. It could also be reused by classrooms in Kyoto to adjust their cameras. Therefore, service architecture in Open Smart Classroom facilitates the cooperation of the service resources in each classroom, enhancing the functionality of newly joined classrooms and improving the efficiency of building new classrooms.

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(iii) Enabling New Classroom to Join In :

The service architecture enables new classrooms, even if it is not built on Open Smart Platform, to join in as long as they follow the Web-Service-based standard specification of Open Smart Classroom, such as invoking SPAW and providing Web service for WSWA to invoke. Although, currently, our specification still has its limitations, which are elaborated in Section 5.3.1, the service architecture offers the possibility for different types of classrooms to join in to some extent.

(iv) Mobile Devices:

The service architecture helps the users to use mobile devices to access Open Smart Space more easily. With the help of OSPG, the teacher can control the PPT through his Smart Phone, and the students can view shared slides on their mobile devices.

III. METHODOLOGY:

In this section, we explore about open smart space, open smart platform;

1. OPEN SMART SPACE:

With the development of Smart Space, we propose three successive phases of Smart Space:

(i) Individual Smart space, Open Smart Space, and Smart Community:

as in Fig. 2. 1. Individual Smart Space. In the first phase, the research focuses on building a smart human-computer interactive space. It emphasizes the communication and the coordination mechanism among the software modules in a relatively close space. Modules in Smart Space are loosely coupled in order to maintain a robust system and embedded technologies are involved to remove the computing devices from people's sight. The Smart Classroom project is mainly in this phase.

(ii)Open Smart Space:

In the second phase, the personal mobile and handheld devices become popular in a pervasive computing environment.

These devices, roaming with the users, can discover the existence of a smart space environment, spontaneously making use of the resources and the services in the space to perform the tasks. Service-oriented communication channel between inside and outside of Smart Space is also created to bridge the inside and outside by services, helping the system to manage and utilize both inside and outside resources. Invoking outside services and encapsulating the modules of inside modules to be the services are studied in this phase. Moreover, Open Smart Space opens its interfaces to allow other Smart Space systems to connect in, aimed at building the preliminary basis for the Smart Community phase.

(ii) Smart Community:

In the third phase, as discussed by researchers in [24], it is almost impossible to establish a union of pervasive computing environments all over the world in the near future, where numerous self-governed Smart Spaces will exist by themselves. Smart Community, which consists of multiple Smart Spaces, is considered as the research object of Smart Spaces. Interspace operation and interspace resource management mechanism among multiple Smart Spaces to be studied in this phase. Referring to the three phases above, the requirements of classroom-based learning system introduced in Section 1.1 corresponds to the research issues in Open Smart Space, thus making the classroom-based learning system an Open- Smart-Space application.

2. OPEN SMART PLATFORM:

After presenting the motivation of Open Smart Classroom and its background of Open Smart Space, we are going to specify the details of its software infrastructure, Open Smart Platform, which is the basis of Open Smart Classroom.

(i) Previous Smart Platform:

Smart Platform [27] is a generic software infrastructure for connecting and coordinating various software and hardware modules in smart spaces to perform specified tasks developed by Tsinghua University. Since most of the modules in smart spaces are parallel working processes and have no centralized control logic, Smart Platform adopts the Multiagent System (MAS) model and thus in nature is a MAS.

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In the runtime environment, Smart Platform consists of three main modules: Agent. An Agent is the basic encapsulation of the software modules of the systems. Agent provides the interfaces for the module to communicate with other Agents in Smart Space. Directory service (DS). One instance of this component lies in the center of Smart Platform and provides the functions: registration of the agents, DS, and message dispatching Container. One instance of this component runs on each computing devices as a daemon process. It acts as the mediator between the Agents running on the same host and the DS.

The Container builds a local environment for the agents, making the details of the low-level communication transparent to the agent developers and provides a simple communication interface for Agents. To optimize the performance of the intermodule communication, Smart Platform adopts three communication schemes suitable to different QoS:. Publish-and-Subscribe scheme with notion of Message Group for instant message. Stream scheme for live data stream, and bulk scheme for reliable bulk transfer of data.

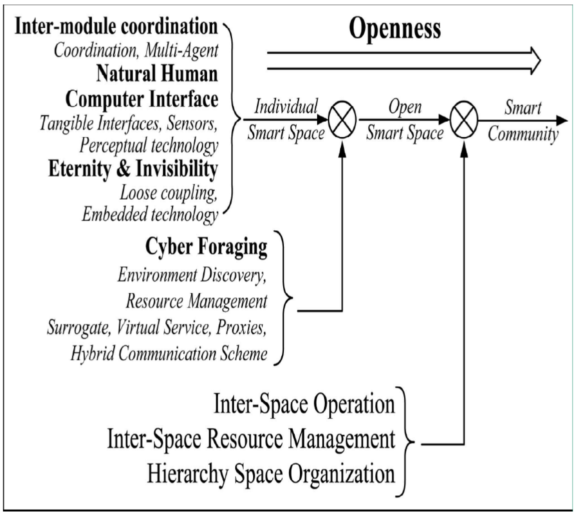

Fig. 2. The three successive phases of Smart Space

(ii) Architecture:

Open Smart Platform is developed based on Smart Platform, inheriting the contributing features from Smart Platform, such as MAS architecture and DS-Container-Agent hierarchy. Two Agents and several other modules are added to provide more extensibility and scalability. Sections 3.2.1 and

» explores two viewpoints, respectively, for single Smart Space and for Simple Smart Community.

» Single Smart Space

From a single Smart Space view, the Open Smart Platform is described in Fig. 3. Similar to Smart Platform, Open Smart Platform has a central DS, several Containers running on each host, and a number of Agents. The reason why we inherit the multiagent architecture of Smart Platform is because it is suitable for Open Smart Space, where the modules are more dynamic and autonomous. Also, inheriting the previous architecture keeps the compatibility with the previous work on Smart Platform. The key improvement is adding three system modules: Web-Service-Wrapper-Agent (WSWA), Smart-Platform-Agent-Webservice (SPAW), and Open-Smart-Platform-Gateway (OSPG).

WSWA and SPAW connect other agents in Smart Space by Smart Platform, while OSPG interacts with Smart Space by invoking SPAW's Web services. WSWA. WSWA is an agent, which invokes an outside Web service based on the message received from other agents and returns the reply from the Web service to the agents. Agents in Smart Platform can invoke outside Web services by sending messages to this agent. . SPAW. SPAW is a Web service deployed on Axis [28]. It receives messages from outside systems, transforms the messages to the protocol used in Smart Platform, creates a SPAW-agent to dispatch the message, and returns the reply from the agent to outside systems.

Through this mechanism, outside systems can interact with agents in Smart Platform as Web services. It also allows us to create and deploy workflows, such as BPEL [19], which allows the developers to customize their tasks more easily. Moreover, as a Web service, SPAW can be easily invoked by a Web page server, where almost all current mobile devices can browse Web pages and thus interact with modules inside the Smart Platform through SPAW. SPAW provides two Web service interfaces: send message number Response and send message Has Response. The former is used if the services requester is NOT concerned about the result from the services. Otherwise, the latter is used to get the result from the services. OSPG. OSPG is a Web application serving as the proxy between mobile devices and Smart Space.

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It consists of a servlet deployed on Tomcat [21] and several Web services deployed on Axis [28]. Specifically, the servlet builds Web pages for mobile devices

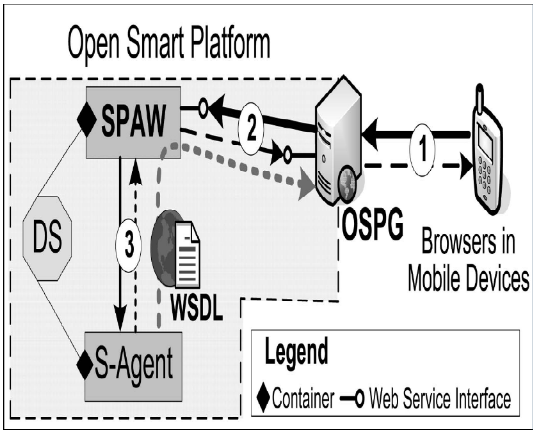

Fig. 4. Mobile device accesses service through OSPG with time-out concerns.

1) Polling mechanism to avoid time-out between the browsers and OSPG. 2) Asynchronous invocation between OSPG and SPAW to address services that takes a long time to complete. 3) SPAW sends a message to request the service on the service agent (S-Agent) and gets the result through Smart Platform. Note that when S-Agent registers its service, its WSDL file is sent to SPAW, which transfers it to OSPG. OSPG creates the corresponding HTML pages dynamically in terms of these WSDL files. To use their browsers to interact with the services inside Smart Space; the Web services is to receive necessary messages from SPAW. The detailed mechanism is illustrated in Fig. 4. There are time-out issues when the mobile device uses a browser to access the service whose result is needed that takes a long time to complete (Fig. 4). There are two kinds of time-outs in the process. The first time-out may occur between the browser and OSPG, and the second one occurs between OSPG and the S-Agent. We use polling mechanism (note 1 in Fig. 4) and the asynchronous invocation (note 2 in Fig. 4) to address these two issues: 1) When mobile devices access the OSPG Web page to invoke the service inside Smart Space, and OSPG generates a UUID and redirects the mobile device browser to a waiting page with this UUID. This waiting page will periodically update itself by Java- Script, sending a request with this UUID to check whether the result is available. 2) At the same time, OSPG uses asynchronous invocation to invoke SPAW to send the service request with this UUID.

After the process of theS-Agent completes, SPAW notifies OSPG with the pair of the UUIDs and the result using which OSPG generates the result page, and the mobile devices get the final resulting successfully.

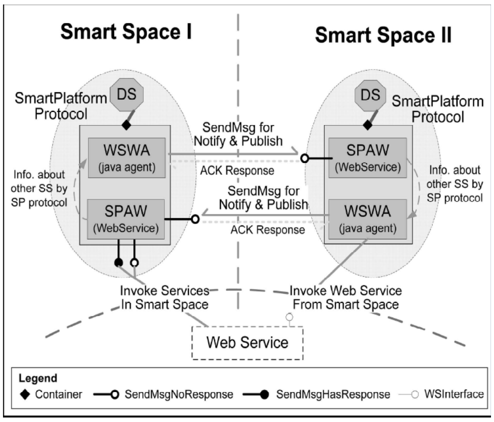

Fig.5.Open Smart Platform runtime architecture for two Smart Spaces

Note that OSPG is not able to initiatively notify the mobile browser unless the browser periodically updates itself to query OSPG, which is similar to the polling mechanism mentioned above (note 1 in Fig. 4). For example, if the student is viewing shared PPT files on his mobile devices through the OSPG Web page This Web page will periodically update itself to check the current index of page presented and synchronize the slideshow on the mobile browser with it. As the number of the services inside Smart Platform increases, creating Web pages for accessing each service becomes cumbersome. Therefore, we require each service, which is accessible from outside Smart Platform to provide its WSDL file when it registers into the system.

Referring to Fig. 4, OSPG collects these WSDL files with the help of SPAW, automatically generating a link for each service on its index page. If the service has no input parameter, the link is the entrance for the mobile devices to invoke. Otherwise, each link directs to a HTML Web page with input forms dynamically generated by the corresponding WSDL file, which is similar to what the SOAPClient [7] does. This mechanism enables the users to access the services inside Smart Space by the browsers on their mobile devices. In short, Open Smart Platform for single Smart Space is a MAS with WSWA, SPAW, and OSPG as the access points for enabling the communications between the inside and outside of Smart Space.

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From the inside view, all of the communications are based on Smart Platform Protocol, which is familiar to previous Smart Platform developer. From the outside view, all of the interfaces are a Web service, which facilitates the Web service developer to build their tasks. Using WSWA, SPAW, and OSPG, we fill the gap between the Smart Space and outside systems, which opens Smart Platform to the outside.

Simple Smart Community:

For simple Smart Community, where several Smart Spaces communicate and coordinate with each other, we establish the communication channel among them in an open network. Taking two Smart Spaces as the simplest Smart Community for example, the architecture is shown in Fig. 5. As mentioned above, WSWA and SPAW are the access points between the inside and the outside of Smart Space. Therefore, we use WSWA and SPAW to exchange messages between Smart Spaces. Using Web Service technology with an HTTP protocol to establish the communication channels between each pair of access points is the ideal and standard way for the open network, where the network environment is limited compared to Local Area Network inside Smart Space.

In single Smart Space and the previous Smart Platform, agents publish messages to a specific message group, and agents who have subscribed to this message group will receive these messages. This publish-subscribe coordination mechanism has been proven to be well scalable and resilient in existing Smart Space projects [12], [3], [32], which provide their own publish-subscribe protocols. In order to be compatible with the legacy Smart Platform modules, which were developed and used successfully in real educational institutions from 2001 with a self-defined publish-subscribe mechanism, we extend this mechanism, aiming at applying it not only to single Smart Space but to Smart Community as well.

IV. PROPOSED METHODOLOGY FOROPEN SMART CLASS ROOM:

Besides providing the features such as real-time interactive virtual classroom integrated with multiple human-computer interfaces, Open Smart Classroom emphasizes openness to provide a new experience for the teachers and students: . Enabling two classrooms to bind in the open network Enabling two classrooms to have class together, especially for those in different countries, has great significance in intercultural and intercontinental learning. Open Smart Classroom tries to connect two Smart Classrooms together to give a novel experience for the teachers and students in the class. Considering the differences of the classrooms and their participants, simple sharing of the video and voice are inadequate. It is necessary for Open Smart Classroom to provide new mechanisms for the teachers and students to learn in this intercultural environment. Current focus is mainly on the differences of languages used in different classrooms. We use Language Grid communication tools [20], [30] to enhance the understanding. Locating a classroom in an open network Open concept is also for a single classroom. A Web-based communication scheme is established, deployed in open network for mobile device to communicate and interact with the classroom. Moreover, the classroom easily makes use of the abundant dedicated services in the open network. For example, Language Grid translation service is used to translate the English PPT into Chinese in order to help the students understand. Additionally, the administrator is able to modify the workflow of the task in open network to meet the different requirements.

(i) Classrooms Setup:

Two classrooms are established, one is at Tsinghua University, China, another is at Kyoto University, Japan. Fig. 1 shows the snapshot of these two classrooms. Tsinghua's classroom is a 6.5 _ 5.5-meter room with four projectors and the classroom of Kyoto is a 10.0 _ 3.0- meter room, which has three LCD screens. Besides these display devices, there are multiple software modules working together in two classrooms, respectively, providing the functionality of these collaborative classrooms. Fig. 6 illustrates the detailed runtime architecture of these two classrooms. Both of the classrooms run on their own Open Smart Platform, consisting of DS, SPAW, WSWA, OSPG, several Containers, SameView Agent, PPTController Agent, and PPT Display Agent. Every participant brings his Laptop to join in the class using Langrid Blackboard tools to discuss with each other. In an open network, Language Grid Server provides the machine translation service that can be utilized in each classrooms.

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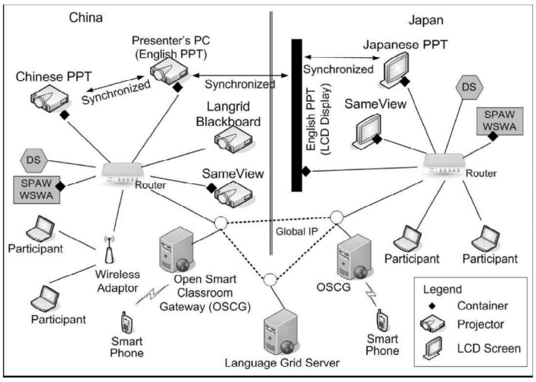

Fig. 6. Runtime architecture of Open Smart Classrooms in China and in Japan Note that this figure shows the architecture when the presenter is in China, which makes the Chinese classroom the main classroom.

» SameView Agent

SameView Agent [31] enables people in two classrooms to see and hear each other. Remote students are also able to use SameView client to join in the class, listen to the instruction, and answer questions. SameView Agent is designed for large-scale deployment over the Internet, thus has enhanced scalability in open network environment.

» PPTController Agent

PPTController Agent runs on the Presenter's PC. It translates the Presentation file and dispatches it to other PPTDisplay Agent. It also detects the status of the slideshow, such as the current page of the slideshow, and synchronizes all the presentations in the classrooms.

» PPTDisplay Agent

PPTDisplay Agent runs as a daemon process to control the presentation file on its host. It receives the presentation files and the controlling commands from PPT Controller Agent to show the presentation synchronously.

» Langrid Blackboard

Langrid Blackboard is a virtual blackboard for students to discuss with each other. It automatically provides machine translation to fill the gap of the language differences among the participants.

In addition, Langrid Blackboard provides real-time back translation mechanism. Back translation mechanism enables the user (e.g., Japanese) to see the translation (e.g., En2Ja) of the translation (e.g., Ja2En) of the input sentence, which makes the user is able to revise his input sentence if the backtranslation has great difference from the original input one. Moreover, it also acts as a feedback platform for students to post their questions and suggestions to the teacher.

» Language Grid Server

Language Grid Server provides the machine translation Web Service in the open network. It is invoked by PPT-Controller and Langrid Blackboard and helps them to translate the requested content.

» Open Smart Classroom Gateway (OSCG)

Each classroom has its own OSCG developed based on OSPG settled in WAN. It automatically generates an HTML page for mobile devices to invoke services in its own Smart Classroom, e.g., turning the PPT to the next page. It also provides some manually built page, such as uploading PPT and viewing current slides show, to facilitate the teacher and students to participate with their mobile devices.

(ii) Experimental Scenario:

The experimental scenario is designed as an intercontinental class between Tsinghua, China, and Kyoto, Japan. The scenario can be divided into two parts: the first part focusing on the teachers and the second one focusing on the students.

- **Part 1**

Teacher Pierre enters a smart classroom in Tsinghua, with an English PPT in his own smart phone. Pierre uploads his PPT file through the OSCG by Web browser on the smart phone. When the file is uploaded successfully, the Web site redirects to a link invoking the Prepare-PPT-Workflow of this scenario. The PPT file is automatically translated from English into Chinese and Japanese using Language grid Web service. Then, Pierre still uses his smart phone to select his uploaded PPT and start the presentation.

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The English and Chinese PPT slideshows are launched on two projectors in Tsinghua, while the English and Japanese versions are shared to Kyoto and displayed on two LCD Screens in Kyoto. As the class goes on, Pierre uses his smart phone to control the presentation such as Turn-to-Next-Page by clicking the link given on the OSCG. And, all the PPT in English, Japanese, and Chinese are turned to the next page synchronously

- **Part 2**

As Pierre gives his class, Miyata, who is in Kyoto has some questions about this presentation. Avoiding interrupting the presentation, he raises his question in Japanese using Multilanguage Chat Agent. Weijun, in China, who sees the question that has been translated into Chinese, answers his question in Chinese. However, the answer is incorrect. Pierre sees both the question and answer on Langrid Blackboard in English. To avoid misunderstanding, he stops his presentation at an appropriate time, gives the correct answer, and then continues his presentation.

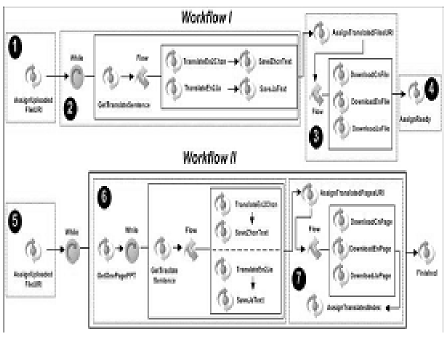

Fig. 7. The implementations of the two types of Prepare-PPT-Workflow.

Workflow I translates the whole PPT at one time and consists of four parts in sequence: 1) Initialization. Get the uploaded file and fileURI. 2) Translation. Get each textline from PPT file and translate it into Chinese and Japanese; then, save them into new PPT files. 3) Share. The PPT files in English, Chinese, and Japanese are downloaded to the corresponding machine. 4) Ready for presentation. The teacher is allowed to start the presentation. On the other hand, Workflow II translates the PPT in an incremental way: 5) Initialization. 6) Incremental translation. Extract one page from the PPT, translate it into Japanese and English. 7) Share. The one-page PPT file in English, Chinese, and Japanese are downloaded to the corresponding machine, which binds each of these one-page PPTs into an integrated one on their machine.

(iii) Workflow Implementation:

After the brief description of the workflow in Open Smart Classroom in Section 4.2, a detailed introduction of its implementation will be discussed. The workflow is designed using Active-BPE L tool, which enables us to visually create workflow process, avoiding tedious and error-prone hand-coding job. By Active-BPEL designer, it is easy to modify the workflow to meet different circumstances and establish new classrooms. Fig. 7 shows the workflow of Open Smart Classroom in detail. It is invoked when the teacher uploads his PPT with his Smart Phone. We provided two types of implementation of this workflow: One-Time way (Workflow I) and Incremental way (Workflow II). In One-Time way, the PPT file is translated as one time, but the teacher could not start the presentation until the whole workflow finishes. In the incremental way, the PPT file is divided into many small PPT segments, each of which co ntains only one page of the original PPT. These small segments are sequentially translated and shared to each client, which combines the shared segments into a PPT file again. The teacher could start presentation as long as the first few pages of PPT have been translated and shared. This w orkflow is more convenient that the teacher do not need to wait until the whole translation of PPT completes. However, the total time of running the former workflow is less than the Incremental way (Table 2). Both of the workflows are easy to modify by Active- BPEL to meet the new demands of Open Smart Classroom.

If the presenter's PPT is in other language, such as in Germany, we could simply change the invocations of "TranslateEn2Chzn" and "TranslateEn2Ja" to similar services like "TranslateDe2Chzn" and "TranslateDe2-Ja," then deploy the workflow again. Moreover, if the class is in one classroom of Tsinghua rather than two classrooms in Tsinghua and Kyoto, it only needs to remove the Japanese related objects in the workflow and deploy it. Last, Active- BPEL designer not only facilitates our work on the deployment of classroom but also helps us to monitor the task status in the classroom by its administration tools on the Tomcat Web server. Besides the Prepare-PPT-Workflow, other sample workflows are also considered. In pervious Smart Classroom, the teacher can use LaserPointer to interact with the classroom such as serving as a remote mouse to control the PPT (i.e., LaserPointer-Mouse) and to select remote students. The whole task is embedded in the LaserPointerAgent itself, lacking reusability and customizability. In contrast, in this kind of scenario, a person uses human-computer interface, such as LaserPointer, to interact with the space, which can be generalized to a workflow in Open Smart Space. This consists of three parts sequentially: 1) Capture-Raw-Service.

TABLE 2 Time of Running Upload PPT Workflow

	Exp.ppt	Conf.ppt	Tsinghua.ppt	Kyoto.ppt
size(KBytes)[1]	120 / 219	1824 / 2078	8425 / 11187	976 / 4400
pages	5	20	49	24
sentences	18	39	143	173
minTime(s)[2]	37 / 40	140 / 148	562 / 667	380 / 501
maxTime(s)[2]	42 / 47	200 / 211	622 / 742	470 / 597
totalAvgTime(s)[2]	38.4 / 43.9	153.6 / 165.7	603.2 / 713.2	413 / 538
transAvgTime(s)[3]	33.2	93.6	373.2	383

[1] x / y: x denotes the size of the ppt file; y denotes the total size of all the segments of the ppt.
[2] x / y: x denotes the time consumed by running the workflow for one time way; y denotes the time consumed by running the workflow by incremental way.
[3] Average time of translation without downloading PPT to each machines

(CRS) recording the events given by human-computer interface, 2) Identification-Service (IS) recognizing the event as a given defined semantics, and 3) Task-Service (TS) invoking related tasks in terms of the recognized semantics. If we want to use a new controlling device such as using the camera in the smart phone as a Camera-Mouse, we simply need to develop their CRS and create a new workflow for supporting Camera-Based Mouse by connecting new CRS with pervious IS and TS. Therefore, the Camera-Mouse has the same function with LaserPointer-Mouse in Open Smart Classroom. Note that the TS could also be changed with another task service easily, which makes the function of Camera-Mouse and LaserPointer-Mouse customizable.

V CONCLUSION:

The presented paper based on one-hop data broadcasting from a single superuser to other users in MSNets. The main idea be-hinds this is exploring both geographic and social properties of users mobility to facilitate data dissemination on purpose. We explore the geographic and social regularities of user's mobility from both theoretical and experimental perspectives. Based on the exploited characterization, we introduce a semi-Markov process for modeling user's mobility.

The proposed superuser route comprises several geo-communities and the according waiting times, which are both calculated carefully based on the semi-Markov model. Extensive trace-driven simulation results show that our data broadcast schemes perform significantly better than other existing schemes. We also discuss multiple superuser scheduling and incentive schemes in selfish MSNets in the Appendix.

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