INFOSTATION-BASED ADAPTABLE PROVISION OF M-LEARNING SERVICES: MAIN SCENARIOS

Ivan Ganchev, Stanimir Stojanov, Máirtín O'Droma, Damien Meere

Abstract: This paper presents an adaptable InfoStation-based multi-agent system facilitating the mobile eLearning (mLearning) service provision within a University Campus. A horizontal view of the network architecture is presented. Main communications scenarios are considered by describing the detailed interaction of the system entities involved in the mLearning service provision. The mTest service is explored as a practical example. System implementation approaches are also considered.

Keywords: InfoStations, intelligent agents, multi-agent system, CC/PP, UAProf.

ACM Classification Keywords: K.3.2 Computer and Information Science Education, H.3.4 Systems and Software.

I. Introduction

The InfoStation-based system described in this paper is established and operates across a University Campus area mainly for the purposes of the mobile eLearning (mLearning) process. It provides "many-time, many-where" wireless services accessible via mobile devices (cellular phones, laptops, personal digital assistants–PDAs) through geographically intermittent high-speed connections. In this paper, we focus on the main communication scenarios of service provision and show how the different components of the network architecture collaborate to facilitate one particular service, namely the mLecture service. We emphasize the service's ability to adapt to the changing environment/context including the change of the mobile device and/or the change of the access network/InfoStation.

The rest of the paper is organized as follows. Section II presents briefly the InfoStation-based network architecture. Section III illustrates the mTest service provision outlining sample interactions between system entities following the four main communications scenarios. Section IV outlines some implementation issues, and finally Section V concludes the paper.

II. InfoStation-based Network Architecture

The following InfoStation-based network architecture provides access to mLearning services, for users equipped with mobile wireless devices, via a set of InfoStations deployed in key points around a University Campus (Ganchev, Stojanov et al. 2004; Ganchev, Stojanov et al. 2006; Ganchev, Stojanov et al. 2006). The InfoStation paradigm is an extension of the wireless Internet as outlined in (Adaçal and Bener 2006), where mobile clients interact directly with Web service providers (i.e. InfoStations). The 3-tier network architecture consists of the following basic building entities as depicted in Figure 1: user mobile devices, InfoStations and an InfoStation Center.

The users request mLearning services (from their mobile devices) from the nearest InfoStation via available Bluetooth (IEEE 802.15 WPAN), WiFi (IEEE 802.11 WLAN), or WiMAX (IEEE 802.16) connection. The InfoStation-based system is organized in such a way that if the InfoStation cannot fully satisfy the user request, the request is forwarded to the InfoStation Center, which decides on the most appropriate, quickest and cheapest way of delivering the service to each user according to his/her current individual location and mobile device's capabilities (specified in the user profile). The InfoStation maintains an up-to-date repository of all profiles and eContent. The InfoStations themselves maintain cached copies of all recently used user profiles and user service profiles, as well as a local repository of cached eContent.

In the following section we describe the provision of one particular service, the mTest service, in more detail.

III. mTest Service

The multi-agent approach to the structuring of the system is adopted as most suitable. In order to facilitate flexible and adaptable service provision, the intelligent agents, residing within each of the three tiers of the system

architecture, must interact so as to satisfy in the 'best' possible way any user requests they might encounter. The mTest service provides a means for educators to evaluate the student's acquired knowledge. It therefore allows the educator to sense whether the students are grasping the material being presented, and judge the best pace with which to cover topics. The mTest service also allows the educator to shape the learning experience of the students, ensuring their focus is drawn to the most relevant material. From a student's perspective, it can also provide valuable feedback concerning their progress, which can be the source of great motivation for the student to work hard, or indeed work harder. The provision of a multimedia mTest service can aid users in maintaining a high level of concentration and actually become more engaged in the material, and as such provide an optimal learning environment.

However for this service to be successful, synchronization of the off-line eLearning process with the on-line mLearning process is imperative. Synchronization is especially important in an InfoStation scenario due to this paradigm's geographically intermittent connection (mobile users come in and out of range/contact with the InfoStations), as demonstrated later in this section. However the Personal Assistant, installed on the user mobile device, allows the user to continue to utilize the mTest while at the same time maintaining the user service profile. Thus the student may complete the test while outside the contact range of any InfoStation, with the user service profile reflecting the student's progression. Once the intelligent agent (Personal Assistant) comes within range of another InfoStation (*'Change of InfoStation'* scenario), this InfoStation will authenticate, authorize, and account the user. The Personal Assistant analyses the user *mTest* service profile, and sends the updates to the InfoStation (delivery of the completed mTest for grading purposes). The InfoStation forwards this updated user service profile to the InfoStation Center in order for the student's assessment to be graded and the *mTest* service profile to be updated. The control information included in this profile update allows the educator to monitor the students test scores and their progress through the assignments (i.e. time spent for each question + total time). Once this grading is complete, the InfoStation Center sends the assessment results back to the InfoStation, which then forwards the results to the Personal Assistant and the student, so that s/he can review them and gain valuable feedback about his/her own performance. The student is then free to continue onto other test, assessments or assignments, or chose another service.

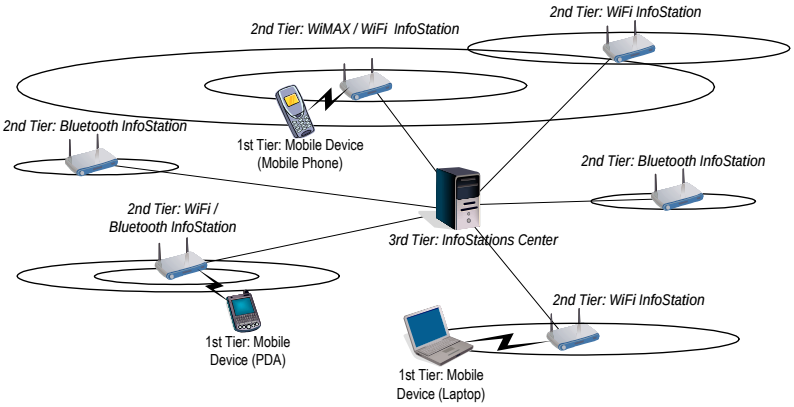

Figure 1. The 3-tier InfoStation-based network architecture

However, before an mTest can be successfully delivered, the mTest content must be adapted and customized according to the capabilities of the current user device, current access network constraints and the user preferences. For instance, the user mobile device may be limited in its capabilities to play video content in which case video components will be sent in a format that best suits the device, or they may be simply omitted. Indeed the entire mTest service could be offered as a text-based assessment. The user may also choose to access a fully featured multimedia version of the mTest service later, when using a device with greater capabilities (e.g. a laptop). This service adaptation is used to address the shortcomings of some low-end mobile devices while still delivering the services.

Indeed a change of device is only one of a number of scenarios that could take place during the service provision. Due to user mobility (e.g. moving between geographically intermittent InfoStation cells) and device mobility (e.g. switching between devices) the following four main communications scenarios are possible:

- No change;
- Change of user mobile device;
- Change of InfoStation;
- Change of user mobile device and InfoStation.

Within each of these scenarios, the initial interactions between the entities remain the same. We utilize the "Composite Capabilities / Preference Profile" (CC/PP) as the uniform format for the implementation of the user profiles. The Master Profile repository in the InfoStation Center contains descriptions of all registered user devices, i.e. their capabilities and technical characteristics. During the initial AAA procedure, the user's Personal Assistant sends as parameters the make and the model of the user device. An agent working on the InfoStation (or the InfoStation Center) reads the corresponding device's description from the repository and according to this, selects the 'best' format of the mTest content, which is then forwarded to the user. However a problem arises when a user uses a non-registered device as s/he might receive the lecture content in unsuitable format. Thus the users need first to register any new mobile device they want to use within the system. In this case, during the initial AAA procedure the Personal Assistant sends a full description of the user device's capabilities towards the InfoStation Center. The manager agent on the InfoStation registers the user in its local Virtual Address Book and updates user/service profiles, before forwarding the user request onto the InfoStation Center. A Profile Agent within the InfoStation Center (updates and) analyses the user profile stored in its Master Profile Repository.

The Service Agent, in collaboration with the Profile Agent, creates a list of services applicable to the user and makes a service offer to the Personal Assistant, which displays this to the user. If the user chooses the mTest service, s/he then specifies the desired mTest content. The InfoStation checks if it has the most up-to-date version of the desired MTest (in the format that best suits the user) in its local repository of cached eContent. If so, it forwards the mTest content onto the user. On the other hand if the InfoStation does not have the requisite content in the required format or most up-to-date version of the content, it will forward on the user request to the InfoStation Center. The InfoStation Center, having already received the make and the model parameters, retrieves the device description from its central CC/PP repository, and adapts the selected mTest content to the format which best suits the user device's capabilities, access constraints and user preferences. This adapted mTest is then forwarded onto the user. The Charging & Billing Module (within the Business Support Domain of the InfoStation Center) also monitors which formats are utilized to access the content, as each format may have minor differences in costs associated with it.

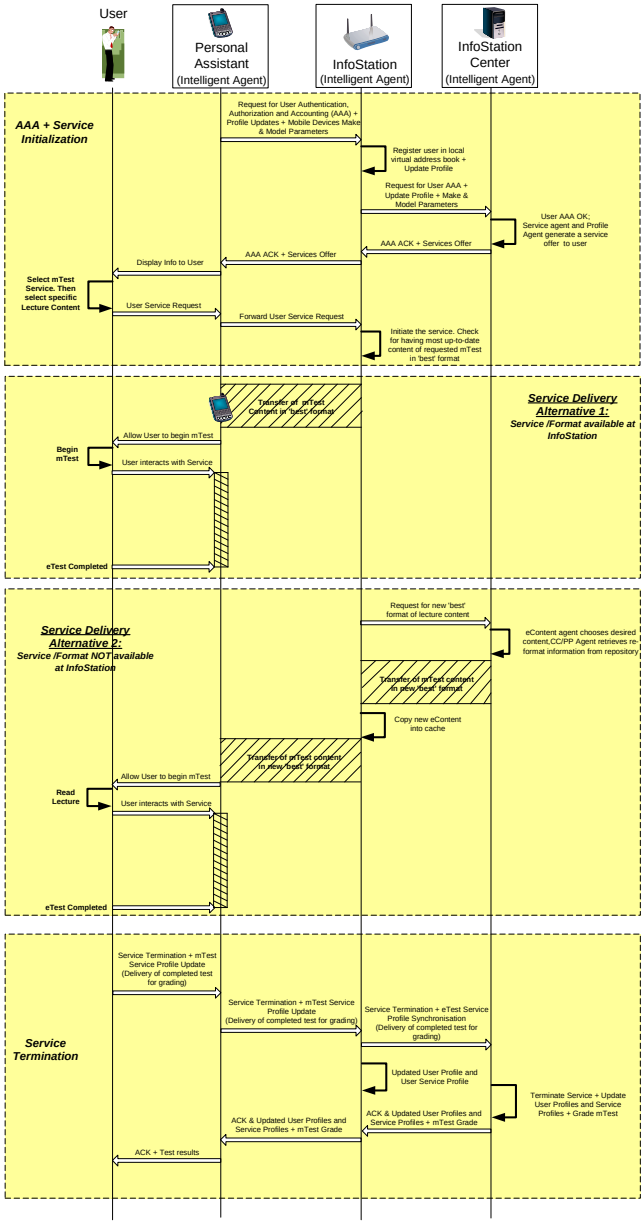

Figure 2. Sample interaction between entities involved in *mTest* service provision in the *'No Change'* scenario

'No Change' Scenario

Figure 2 illustrates the straightforward provision of the mTest service within the system. If the InfoStation can fulfil the user service request (i.e. the required mTest content's format that best suits the current user context is available at the InfoStation), the content is forwarded onto the user.

However if the InfoStation is unable to meet the demands of the user, the request is forwarded

onto the InfoStation Center. Here the eContent manager chooses the required/best format of the content (from the repository) and in conjunction with the CC/PP agent reformats the content and transfers the adapted eContent onto the user's Personal Assistant. The InfoStation will store a copy of this re-formatted eContent in its cache, in case if another user requests the same mTest. Once the service is terminated, the user profile and the user service profile are updated within the InfoStation and InfoStation Centre so as to reflect the progression of that particular user through the mTests.

'Change of Device' Scenario

Due to the inherent mobility of this system, it is entirely possible that during mLearning service provision, the user may shift to another mobile device (e.g. switch to a device with greater capabilities). By switching to a device with greater capabilities, the user may experience a much richer service environment and utilize a wider range of resources. Figure 3 depicts the case where the user switches from a PDA to a laptop, whilst utilizing the mTest service.

In this case, the users Personal Assistant sends a notification of device change to the InfoStation, detailing the make and model parameters of the new device. Then the InfoStation checks its cache for the required/best format to suit the capabilities of the new user device. If the new format is available, the InfoStation immediately forwards this formatted content onto the user's Personal Assistant.

If however, the InfoStation does not have the new required/best format of the lecture, it requests this from the InfoStation Center, which will retrieve it from its eContent repository.

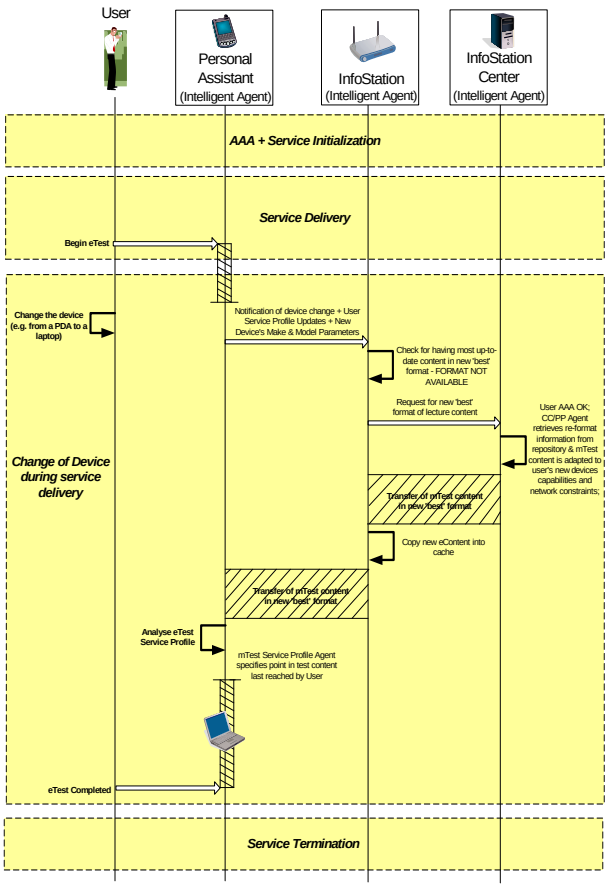

Figure 3. Sample interaction between entities involved in *mTest* service provision in the *'Change of Device'* scenario

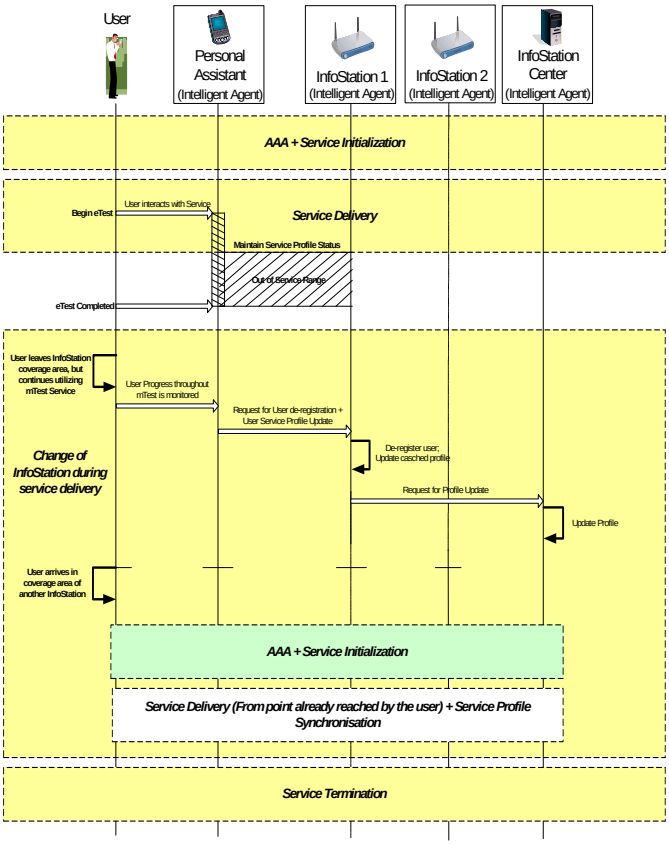

Figure 4. Sample interaction between entities involved in *mTest* service provision in the *'Change of InfoStation'* scenario

'Change of InfoStation' Scenario

Within the InfoStation paradigm, the connection between the InfoStations themselves and the user mobile devices is by definition geographically intermittent. With a number of InfoStations positioned around the campus,

the users may pass through a number of InfoStation cells during the service session. This transition between InfoStation cells must be completely transparent to the user, ensuring the user has apparent un-interrupted access to the service.

The following Figure 4 illustrates the entity interactions involved in the transition between InfoStations. As the user mobile device moves from the coverage area of an InfoStation, the Personal Assistant requests user de-registration from the local Virtual Address Book of the InfoStation. The Personal Assistant also requests one last user service profile update before leaving the coverage area of the current InfoStation. The InfoStation de-registers the user, updates the cached profile, and forwards the profile update to the InfoStation Center to make necessary changes in the Master Profile Repository.

Meanwhile the user continues to progress through the mTest content. The Personal Assistant monitors this progression. When the user arrives within the coverage area of another InfoStation, the AAA and the service re-initialization procedure takes place first. After updating the user service profile, the newly requested sections of the mTest (if any) will be delivered to the user according to the tests completed while out of range of the InfoStations.

'Change of Device & InfoStation' Scenario

We have outlined the separate instances where the user may switch his/her access device or pass between a number of InfoStation cells during a service session. However a situation may arise where the user may change the device simultaneously with the change of the InfoStation. The following Figure 5 illustrates the entity interactions, which occur in this scenario.

Both procedures for device change and InfoStation change (as described in the previous two subsections) could be considered as automatic procedures, independent of each other. Hence each of these may be executed and completed at any point inside the other procedure without a hindrance to it. The two alternatives are shown in Figure 5.

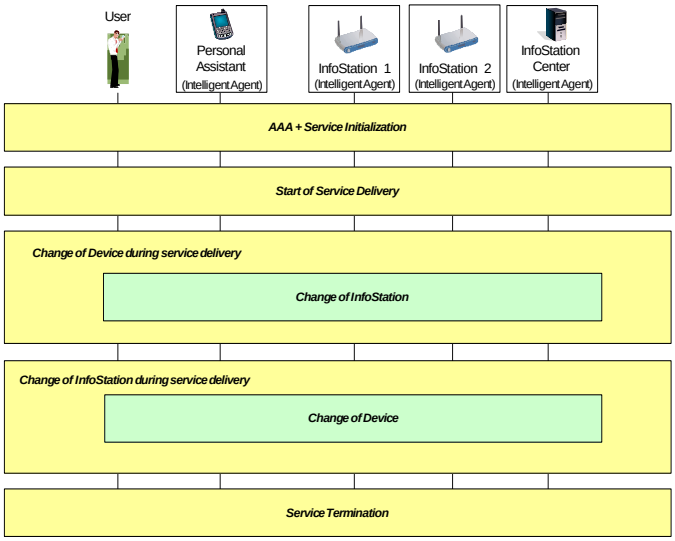

Figure 5. Sample interaction between entities involved in *mTest* service provision in the *'Change of Device & InfoStation'* scenario

IV. Implementation

For the implementation of the User Profile and User Service Profile, which are integral to the facilitation of fully adaptable services, we have opted to use the uniform format "Composite Capabilities/ Preference Profile" (CC/PP) (Kiss 2006). This format is platform-independent and is based on the Resource Description Framework (RDF) (Manola and Miller 2004) and is recommended by the World Wide Web Consortium (W3C). A CC/PP profile is basically a description of device capabilities as well as specific user preferences that can be utilized to guide the adaptation of service content delivered to that device. This adapted and personalized mLearning allows us to offer multimedia content and activities adapted to learners' specific needs and influenced by their specific preferences and context. So when a specific user / mobile device submits a request to use a certain service, the source of that service (i.e. the InfoStation or the InfoStation Centre) customizes and tailors the service content to meet the user preferences and the capabilities of his/her current mobile device. In essence, content is adapted to 'best' suit the individual user and the specific device at that particular time. As we have illustrated in the previous section, the user may change devices a number of times during a service session. So through the customization and tailoring of the services (and their content), these services can be offered to users, independent of the type of mobile devices. This is an essential factor in this type of network, as user devices and preferences will be as varied as the users themselves. A CC/PP profile contains a number of attributes and associated values, which

are used by the InfoStations to determine the most appropriate ('best') format of the resource to be delivered to the user's Personal Assistant.

The User Agent Profile (UAProf) (OMA 2006) specification is a concrete implementation of the CC/PP developed by the Open Mobile Alliance (OMA). This specification builds upon WAP 2.0 (WAP, 2007) and facilitates the flow of capability and preference information between the Personal Assistant, the InfoStation and the InfoStation Center. This specification defines this capability and preference information through a structured set of components and attributes. Components are grouping mechanisms for attributes, therefore in essence, a CC/PP or UAProf profile is organised as a structured set of attributes and value pairs.

The following are the most useful components defined within the UAProf specification. However we could add our own additional components and attributes to better convey capability and preference information within our system:

- *Hardware Platform*: contains attributes that describe the hardware characteristics of the current user device, e.g. device type, model number, input and output methods, screen size, color capabilities, image capabilities, device CPU etc.
- *Software Platform:* contains attributes relating to the operating environment of the device, e.g. operating system name-vendor-version, JVM version, audio & video codecs, Java enabled etc.
- *Network Characteristics:* attributes relating to the network capabilities of the terminal, e.g. bearer characteristics – latency, reliability etc.
- *Application Preferences:* attributes relating to the browser application on the device, e.g. browser name-version, content types accepted by browser, markup languages, scripting languages supported etc.
- *WAP Characteristics:* attributes relating to the WAP capabilities of the terminal, e.g. WAP version, WML script libraries, supported WAP applications.

The different entities within the system can use this capability and preference information to ensure that the user receives service/content that is tailored for the environment in which it will be accessed. However, it is possible to even further customize the service to suit the preferences of the user. This is achieved through the extension of the CC/PP vocabulary. A CC/PP vocabulary defines the format or structure of the profile information, which is exchanged between a Personal Assistant and the InfoStation. While CC/PP and UAProf already define a number of components and attributes to describe the many different capabilities of the user device, we define a number of attributes relating to the user himself/herself, which could be used to further customize and enhance the service for that individual user. The user preference components can specify anything from the user's name, the languages s/he speaks, user's age, location, and the format in which the user would prefer to receive information. Another important attribute within the user profile is to specify the role or job title of the user, i.e. whether the individual is a lecturer or a student etc. Specific groups may be allowed access to different resources related to the service.

Figure 6. Screenshots of *mTest* service execution on devices with varying capabilities.

On figure 6 are two sample screen shots of how this service will appear on mobile devices of varying capabilities. The screen shot on the left represents a device with the capabilities to show complex graphical information. In this case the question posed within the mTest requires the student make an observation, and answer a question regarding the image shown. As this device is capable of supporting multimedia, it may also facilitate an audio element to the mTest.

The device on the right illustrates how a device with more limited capabilities may allow the student to complete the mTest without any multimedia elements. That particular device's profile will specify its capability to only handle text information during its communications with the InfoStations, and as such the InfoStation will provide only the requisite text information.

V. Conclusion

The implementation of the adaptable InfoStation-based mLearning Service Provision within a University Campus has been outlined in this paper. The underlying network architecture has been detailed. The mTest service, which provides a means to evaluate the students acquired knowledge and provide valuable feedback to students concerning their progress, has been described. The entity interactions involved in facilitating this service during the four main communications scenarios have been detailed. The process of adapting and customizing the mTest content according to the capabilities of the current user device, current access network constraints and the user preferences has also been outlined.

The utilization of the Composite Capabilities/ Preference Profile" (CC/PP) format for the implementation of the User/Service Profiles, which are integral to the adaptation of the services, has been outlined. The benefits of using this format have also been considered.

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TECHNOLOGY OF SATELLITE AND MOBILE COMMUNICATION IN MODERN DISTANCE EDUCATION

Viktor Bondarenko

Abstract: This paper describes the use of technology of satellite and mobile communication for quality improving of modern distance education.

Keywords: satellite communication, mobile telephones, training, education.

ACM Classification Keywords: H.4.3. Communications Applications

Introduction

The intensive development of communication systems opens new perspective opportunities for the remote training. The satellite and mobile communication systems are most interesting directions of communication systems, which can be effectively used in the field of the remote training.

The satellite Internet is a unique means of access to the educational Internet-resources in places, where are inconvenient the connection to the Internet through switched telephone channels, dedicated channel or using ADSL-technologies. The satellite channel provides the same fast and reliable data transfer, as well as a dedicated channel.

Such satellite channel enables to receive large volume of the educational information including multimedia manuals, average volume of which is measured in hundreds Megabyte. Because of high-speed access in the Internet, it is possible to see, to listen lectures, and to conduct training in real time mode if the teacher is working with the WEB-camera.

The satellite TV, which is realized on that equipment as the satellite Internet, allows stable and qualitatively to see the educational television programs. Such TV not depends on a territorial location of the television centers and ground transponders.

The means of mobile communication allow to use GPRS (General Packet Radio Service) and EDGE (Enhanced Data for Global Evolution) technology of the data batch transfer [Bondarenko, 2006], due to them it is possible the communication and information exchange between students and teachers practically from any place not only country, but also all continent.

Taking into account above-stated, the specified communication facilities present large interest for the formation of a new technology, which can improve of education quality thanks to more effective contact of students with teachers.

This technology is applied to all forms of training, but in particular, to correspondence and remote forms, because such students have not stable contact with teachers, because, as usually, they are located on large distances from an educational institution. However, the stable contacts of students with the teachers determine quality of received education.