Automated Deployment of a Wireless Mesh Communication Infrastructure for an On-site Video-conferencing System (OViS)

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Nowadays, information and communication technology (ICT) has already brought significant cost savings to several industries. During the construction of a building, modifications may require costly on-site visits of engineers to adapt plans to the new circumstances. ICT such as video conferencing systems may reduce the number of these visits significantly. Video conferencing enables the engineers to remain in the office. But nevertheless they can comprehend any problems and particularities of the complex new situation, adapt their planning, and then instruct the workers on-site. Unfortunately, in-building communication networks, as well as electric installations, are set up very late in the building construction process. In addition, communication over cellular mobile networks (GSM/UMTS) is often not possible inside buildings, especially in basements.

As deviations to the plan are quite common during building construction, an electric installation company's engineers often have to support their electricians in adapting the planning on-site. The costly engineer then spends a lot of his working time by travelling from the office to the construction site. The obvious solution of using a phone often fails due to missing reception of any cellular mobile network at the location of interest, e.g., the switching centers in the basement. Moreover, the situation may be too complicated to be explained on the phone. A picture or video could illustrate the situation more easily. A temporarily disposable communication infrastructure, which enables a telepresence system, would therefore constitute a much-appreciated benefit. It should be simple, straightforward and safe in its deployment. As on-the-fly cable installations are safety risks on a construction site, we have investigated the usability and applicability of a wireless mesh network (WMN) with battery-driven nodes as a temporary communication infrastructure and have developed a first prototype of our on-site video-conferencing system (OViS). The application of WMN for temporary venues and spontaneous networking has also been suggested in [1]. In order to provide "as easy as winking" deployment, OViS includes self-configuration and self-awareness mechanisms and guides the user through the deployment by a wizard application.

We propose to deploy a temporary WMN with battery-driven nodes (see Fig. 1) for the necessary network connectivity to a commonly available DSL or UMTS router. The WMN does not require any existing commmunication infrastructure inside the building and does not introduce additional safety risks. As video conferencing is required to set up the electricity and communication networks of the building, no infrastruture that could be utilised for communication is already available, i.e., power-line communication is not an option for this particular use case. Any temporary wire-based infrastruc-

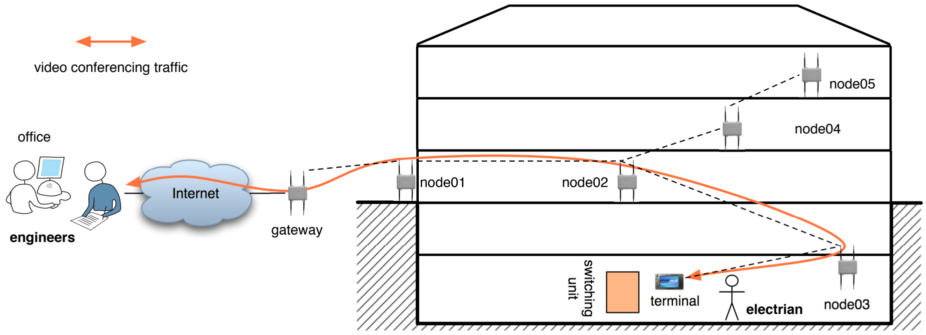

Fig. 1. Scenario for an OViS deployment

ture would either be too time-consuming in the deployment or end up as trip-wire and therefore compromise the work safety.

The on-site video-conferencing system (OViS) prototype consists of a handheld device (Asus Ultra Mobile PC), six battery-driven mesh nodes (PCEngines ALIX) and an Ethernet cable. We have used simple standard indoor enclosures for nodes and batteries for our first functional prototype. In order to comply with the harsh environment at construction sites, we plan to employ the same aluminium weather-sealed (IP-67) outdoor enclosures, which we have used for our meteorological WMN [2], for the next prototypes. In order to provide energy for our application scenario (8-10h network lifetime), the nodes of our prototype are equipped with one lithium-ion polymer batteries (3200 mAh). Depending on the application scenario, the dimensioning of the batteries can adapted.

All equipment of OViS is placed in a bag to provide comfortable handling during the deployment. We face the challenge of simple, straightforward, and fast deployment by non-experts. Self-configuration and self-awareness mechanisms as well as a wizard-based deployment guide support the deployment process. The OViS deployment wizard application runs on the handheld and guides the user through the deployment process. Such support as provided by the wizard application is important to overcome deployment issues such as the non-uniformity of propagation delay of wireless signals, especially indoors.

The OViS deployment starts with the gateway node. The user first grabs the handheld and powers it on. The handheld automatically launches the deployment wizard, which then directs the user to connect the first node to the DSL/UMTS router (see Fig. 2(a)) and to power it on. The gateway configures itself at boot time, e.g., setting the IP address of the Ethernet interface by, e.g., DHCP (IPv4/IPv6), the IP address of the wireless interface using IPv6 autoconfiguration (see Fig. 2(b)), and starting up the ad-hoc routing protocol (Optimized Link State Routing). Then, it announces its presence and its status (e.g., gateway or not) to the handheld device by sending an OViS HELLO message. After deploying the gateway, the OViS wizard on the handheld sends an OViS DEPLOYED_NODE message to the gateway node in order to stop the hello mechanism and to configure additional communication parameters.

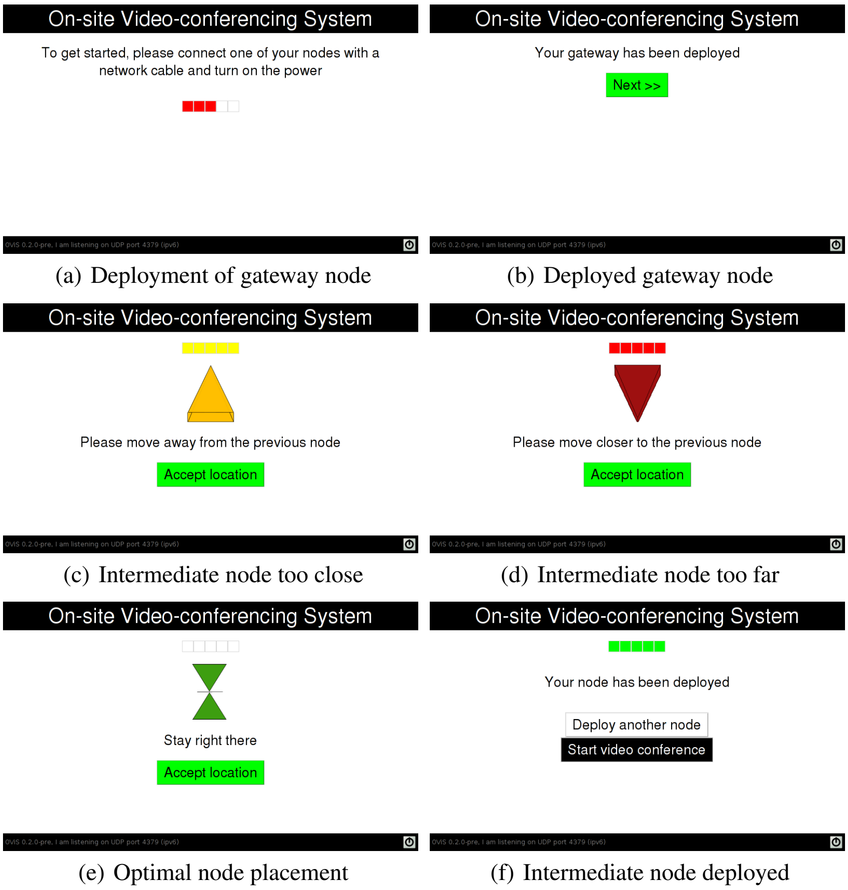

Fig. 2. Screenshots of the OViS deployment wizard application running on a handheld device.

Afterwards, the OViS wizard advises the user to deploy the first intermediate node. The user has to take the next node, power it on, and move towards the installation site. The intermediate node also configures itself at boot time and then announces its presence by an OViS HELLO message. As not being a gateway, the node carries out measurements of the received signal strengths to the previously deployed nodes and transmits them to the handheld. The OViS deployment wizard then uses these signal strength measurements to instruct the user in a proper placement of the next node by giving audio-visual feedback (see Fig. 2(c) - 2(e)). The wizard signals the user if he/she has reached the optimal position for the node (see Fig. 2(f)). Afterwards, the deployment process is repeated for the next intermediate node. Once the installation site has been reached, the user switches the handheld from the deployment mode to the video conferencing system mode (see Fig. 2(f)) and starts the video conferencing application.

OViS supports IPv4 and IPv6 access networks. If IPv6 is supported over the whole communication path, the video conference can take place directly over IPv6. Otherwise, if the communication peer (office) or the access network (DSL/UMTS) are only IPv4 capable, OViS automatically sets up an IPv4 over IPv6 tunnel between the gateway node and the handheld. If so, an additional IPv4 address is configured for the handheld. The current OViS prototype provides a DNS service by using the global Google Public DNS resolution service, which makes OViS less dependent of external services: although implementing a DNS proxy service on the gateway node is also feasible.

After having set up the complete network, the video conferencing application (e.g., Skype) is started on the handheld and the user may communicate with the office and solve his/her installation problem using telepresence. Although the current OViS prototype uses Skype for video conferencing, other applications can be easily integrated.

OViS may also provide a valuable solution for other use cases, e.g., disaster recovery. Currently, we are evaluating the optimal signal strength thresholds to maximise network throughput and their combination when multiple nodes are in range of the active node to be deployed. We plan to extend OViS to support multi-channel communication. Moreover, we are also evaluating different open-source video conferencing applications in order to provide more seamless integration into OViS. Other possible extensions are the integration of a whiteboard, support of file transmits (e.g., technical manuals, annotated construction plans), and enhancing the video with overlay networks.

References

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