

Android Smartphone as a Microphone in SmartRoom System

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Abstract—SmartRoom system implements a service set to assist such collaborative activity as conferences. Services are accessible via personal mobile devices. This work presents our development of Microphone-service for SmartRoom. The service allows a user to transmit her voice from the mobile device to the embedded audio-system of the room. For the case study the client part is implemented on Android smartphones.

SmartRoom is a multi-service system [1] that assists research and educational activities held in a room. SmartRoom users are activity participants; they are present in the room (physically or virtually). Surrounding devices as well as external services form together a smart space—SmartRoom space, where all related data are collected and shared. Smart-M3 platform [2] is used for deploying a SmartRoom space for a given computing environment.

Users run SmartRoom clients on their personal mobile devices (e.g., smartphones or netbooks) and access the SmartRoom space for requesting and receiving available services [3], [4], [5]. For instance, Conference-service constructs and dynamically maintains a conference program of the ongoing activity. Each SmartRoom client can read the program and visualize it to the user. For an active speaker her SmartRoom client forwards commands to the SmartRoom space for control of the slide show (“next slide”, “previous slide”, etc.), which are then executed by Presentation-service and visually reflected on the public screen of the room.

In this work we continue our work [6] on Android client development for the SmartRoom system. We extend the SmartRoom service set with Microphone-service. It makes a personal mobile device a speaker’s microphone. That is, the speaker transmits her voice to the public audio-system (embedded in the room), and the audio is reproduced, covering wider spatial area. At the recent development phase we focus on the use of Android smartphones, while the same approach can be applied for other mobile devices.

The audio flow from a client must be played immediately (i.e., in real-time). The problem is network data transfer delays. For VoIP applications, UDP is widely known as the best option.

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To reduce the wireless traffic volume we experimented with popular LAME and Speex codecs, which provide functions for audio transformation. We apply the codecs for compression of the audio data before network transmission. Architectural scheme is shown in Fig. 1.

The server side of Microphone-service is implemented as a Smart-M3 knowledge processor (KP). We employ SmartSlog SDK [7] for programming the Smart-M3 based access operations. SmartSlog supports ontology-driven development for Smart-M3 and can be effectively used for Android, as we showed in [6]. Programming the logic of KP interaction in the SmartRoom space is written in C/C++. (Android supports native code.) Programming the user interface is based on Java (primary case for Android).

The SmartRoom space is maintained by Smart-M3 Semantic Information Broker (SIB). It is identified with IP address and port. The service KP publishes its valid IP address and port. Consequently, any SmartRoom client can find the contact for direct network communication with the service. Config file describes connection data like Smart Space name, SIB IP and port which is used for connection with Smart Space.

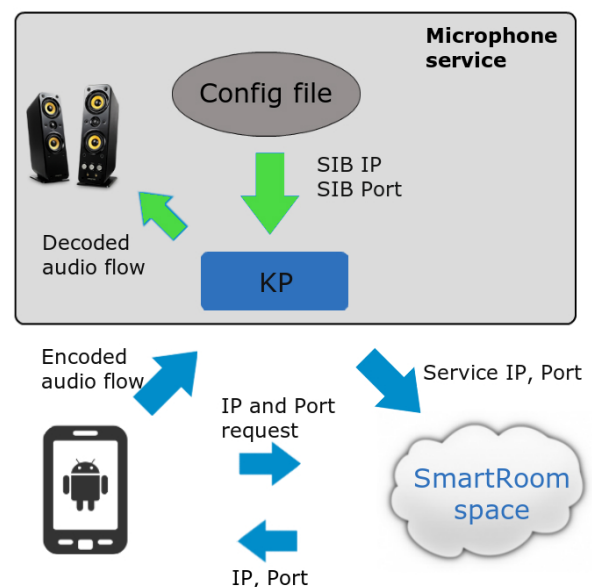


Fig. 1. Architectural scheme for implementing Microphone-service

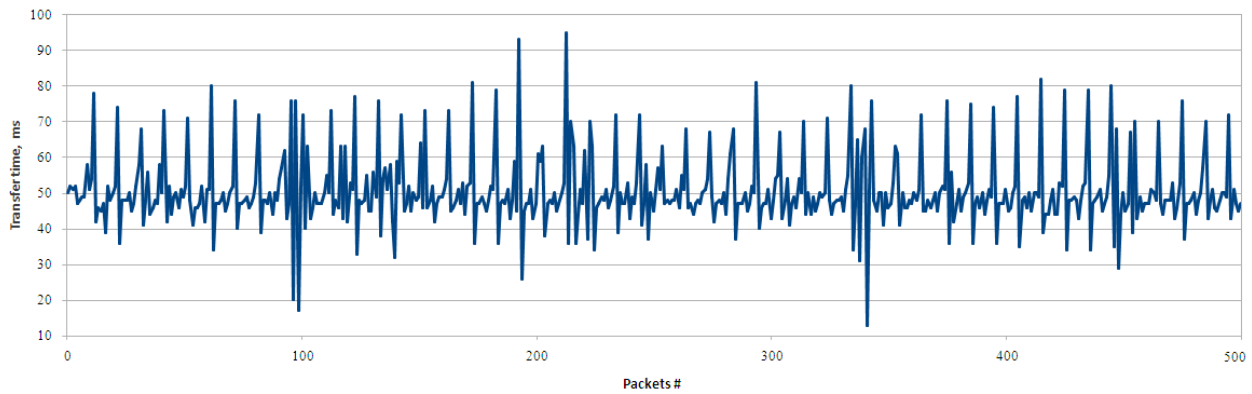


Fig. 2. Performance of wireless network transmission for Microphone-service: X-axis is sequential UDP packets transmitted, Y-axis is the network delay of a packet between a mobile client and its service KP

TABLE I. AUDIO CODEC COMPARISON: LAME AND SPEEX

Audio codec	Observations and comments
LAME	WAV files encoded to MP3 lead to much noise, and recognizable delays in speech reproduction appear frequently. Tuning codec parameters does not change the result. There is no documentation provided for application developers.
Speex	After encoding and decoding the reproduced speech has satisfactory quality: human recognizable delays are sporadic and disappear when the wireless network capacity is high. There is a well documented implementation in Java, easy to use by an application developer.

If a user needs Microphone-service then her SmartRoom client reads the contact from the SmartRoom space. Consequently, the client can directly transmit its audio data to the KP over UDP. Only the active speaker may use the service.

Android devices support audio capture in WAV format. Even in local-area network (Wi-Fi in our case) such an uncompressed format is inefficient for VoIP applications. In our implementation, audio data are first compressed on the client side using Speex codec (<http://www.speex.org/>). It encodes audio data effectively to a specific format of smaller size (and lower quality).

On the server side, the service KP decodes received audio data and plays it using plugged speakers (in-room embedded audio-system). Speex codec is open source audio compression format designed for speech audio data. Speex applies CELP algorithm (Code Excited Linear Prediction). Both client and service KP use JSpeex (jspeex.sourceforge.net), which is a Java port of Speex codec.

We also experimented with another open source codec. LAME is a high quality MPEG Audio Layer III (MP3) encoder (<http://lame.sourceforge.net/>). Our comparison of LAME and Speex is summarized in Table I. We conclude that Speex is more appropriate for speech processing in SmartRoom system. Use of MP3 leads to frequent delays in speech reproduction because of the network has to transmit more amount of data.

Network performance for Microphone-service is shown in Fig. 2. D-Link DIR-320 wireless router is used in the experiments. The plot represents 500 UDP packets of 62 bytes each. The packet flow is from a SmartRoom client to its service KP. We measured the time spent for transmission of a packet. The time cost of encoding and decoding is estimated as a few milliseconds only. It has negligible impact to the total delay compared to the share of network transmission. The average

network transmission delay is $\bar{\tau} = 50$ ms, standard deviation is $\sigma = 6$ ms. The transmission delay τ exceeds $\bar{\tau} + \sigma$ for 68 packets from 500 (i.e., 13.6% of all cases).

Our basic observation is that Microphone-service is sensitive to the capacity of Wi-Fi network. When the capacity is low compared with the traffic passed then recognizable delays appear, worsening the service quality. Notably that high delays easily happen because of inaccurate Wi-Fi router configuration. We recommend selecting the less used channel of the router.

We conclude that Microphone-service can effectively extends the SmartRoom service set. The network delay problem is solved using 1) the open source Speex codec for audio data compression 2) UDP-based data transfer 3) correctly configured router. Although there are other open source codecs for speech, we expect that Speex already provides reasonable performance. The bottleneck is Wi-Fi transmission, thus another codec would not lead to essential improvement.

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