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Interactive Museum Overview – Getting the big picture

DSD – Distributed Software Development Course

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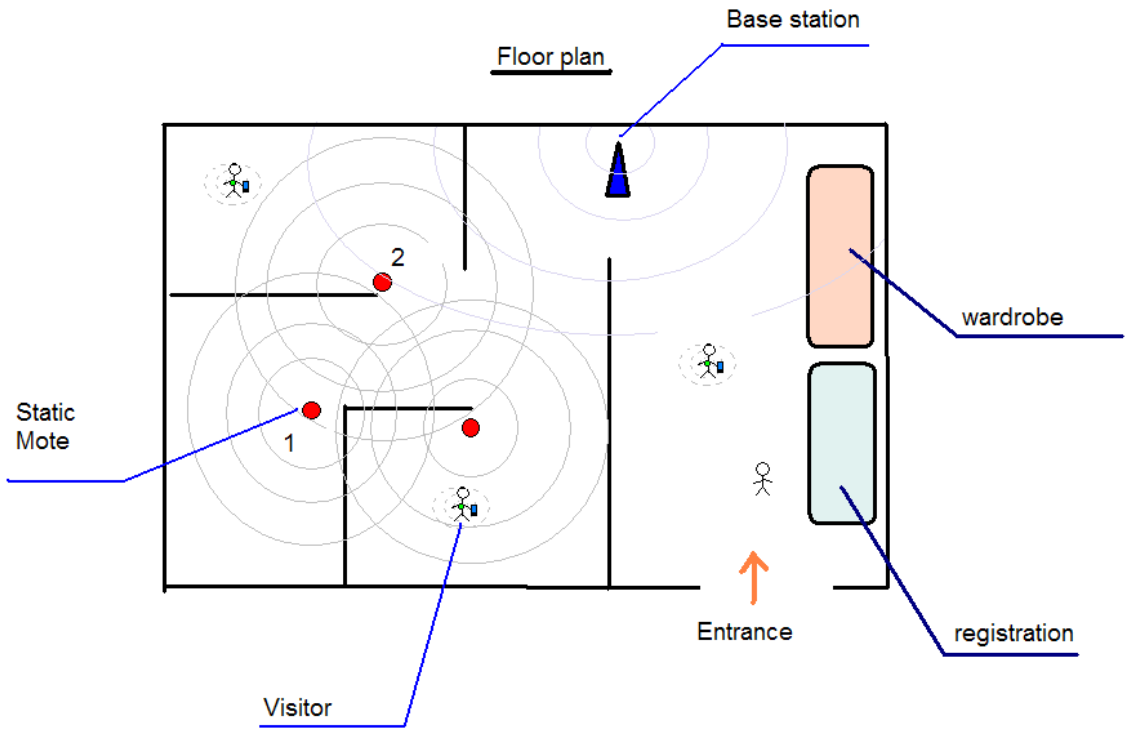
1. Introduction

The idea that stands behind the Interactive Museum is not new and systems that can achieve such interactive functionality are available for several years now. They are mostly based on RFID technology.
The main concept will be explained from the perspective of a visitor who just stepped in the Interactive Museum. In that example focus will stay just on things that are in our sphere of interest. The technical details and design visions and suggestions will be explained later on.

Stepping into the world of new modern interactive museum, visitor will have the opportunity to take part in a unique multimedia experience that won't be limited to museum space only but will go far beyond that.

When visitor enters the museum, if he or she decides to go with multimedia experience visitor will have to register at the ticket office. At the ticket office visitor will get the MOTE, as personal ID and PDA as multimedia interface. Registration is important part of process, and visitors will have to show some official document (e.g. Passport) which will hopefully be enough to stop some of them to steal the equipment.



Picture 1: Floor Plan example

Equipped with MOTE (green circle on picture) and PDA our visitor is ready to start his "journey". Each room on exhibit will have a static mote (red circle) that will register the presence of visitor and depending of room, visitors will get multimedia content on their PDAs (regarding the exhibits exposed in that room). Multimedia content means not only video or audio but

additional information about the exhibits (historical information, pictures, related exhibits, etc.). In the next chapter this document will give more details about the multimedia content.
After the visit, user will return the equipment and go home. Since every move of user was tracked the system must be able to build a personalized web page of visited and not visited exhibits, which will be available to user over the Internet. All the additional materials (video, historical information, pictures, etc) should be accessible through web interface.

2. Technical overview

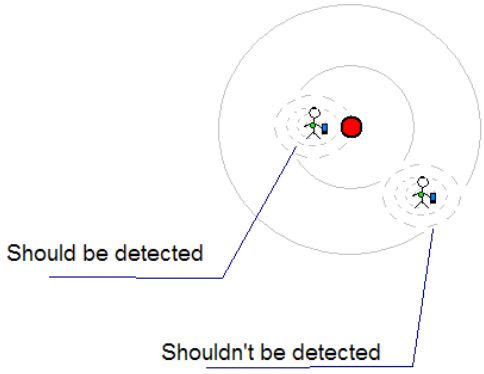
After the short explanation of interactive museum concept this chapter will familiarize the reader with technical solutions. Technical solution is merely a proposal of Croatian DSD team and it should be discussed further on.

As seen in introduction part, system that would enable such interactivity should comprise of 4 different parts. First part is a controlling mechanism for motes (setting up static mote positions, getting the information from/to them, etc.), second one is a personnel interface for registering visitors with their personal motes/IDs, and viewing the status information (number of visitors in particular exhibition room, mote health status, statistics etc.), third one is a PDA application and multimedia content streaming server, and fourth part is web page generation component.

1.1 Mote controlling mechanism and GUI

There are two logical types of motes involved in design (both are physically identical units). There are so-called static motes and dynamic motes. Static motes will be positioned once for each exhibit and will be used for dynamic mote detection and server communication. Each and every mote will have different ID (for example static motes will have IDs from 0-99, and dynamic motes from 100-999) and that will be the distinction mark between motes. Since visitors will be carrying dynamic motes they must be detected by static motes.

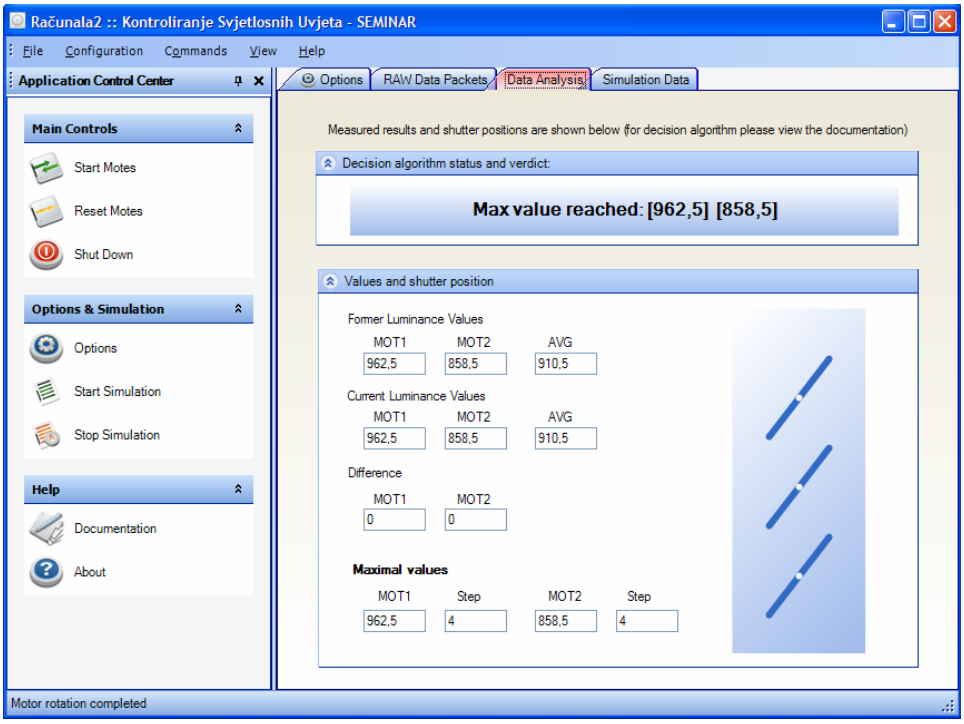
Every mote has its radio range; static mote needs to have big radio range for communication with central radio station, or if one of them is far away from radio station, motes should be gateways for each others so they can tunnel the message to the server from far away mote which is not in radio station range but it is, in other static mote radio signal range. (For example on the picture 1 mote number 1 doesn't have direct radio link with base station (blue triangle) but has a radio visibility with mote number 2 which will tunnel the message to base station)
The position of a visitor needs to be detected accurately, and to achieve that the radio range of dynamic mote has to be very small, so the visitor needs to be very close to the static mote for detection. (**NOTE:** it is possible to adjust radio range of each mote but we haven't tested this yet and we don't know the exact minimal range. The final mote setup will be dependant on that value)



Picture 2: Dynamic mote radio range and detection

Using this method it is possible to detect visitor at each exhibit. (**NOTE:** For the purpose of DSD project we don't want to have more than 2 motes per room, for example one mote for one side of room and another for the opposite side). The range might be a problem because of signal overlap, consider the situation where one visitor is detected by two static motes at the same time, in this situation we wouldn't know where the user is actually. To avoid this problem a very good mote position design application with implemented range evaluation is needed.

GUI design is another important part of project, the author of this document, based on his experience has already suggested a solution.
Application has to have role separation, this means that Administrators and personnel at ticket office will see different application/GUI parts and have different permissions, but there will be only one application with unified visual style. (**NOTE:** The GUI showed on picture 3 is from another project (copyright to Denis Siladi) which is not related with DSD project by any means)



Picture 3: Example of a visual style

Interactive Museum Control Application will have 5 main parts: Application Control Center, Floor Plan (tabbed control), Registered mote status info, Object properties, Zoom function (picture 4).

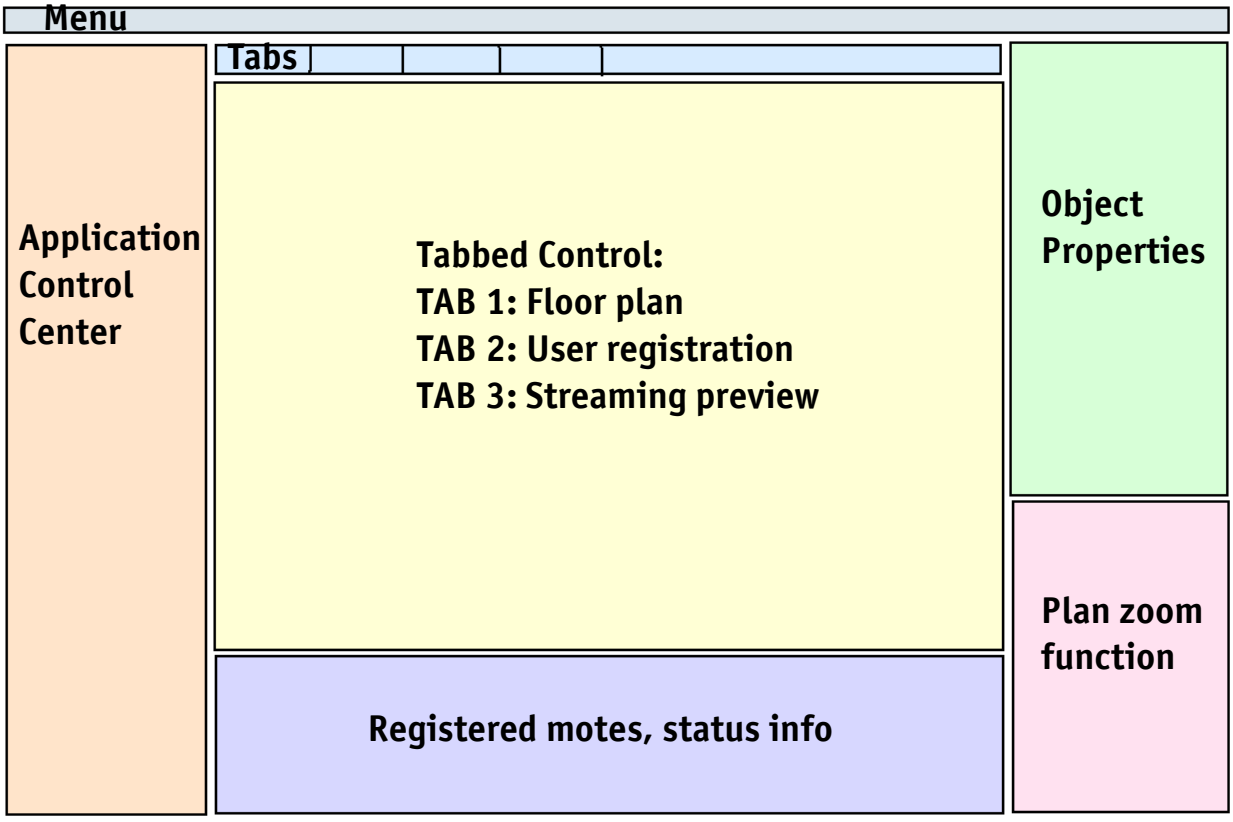
Application Control Center – is a container for mostly used functions

Floor Plan – will contain a floor plan and it should implement drag&drop function so the exhibit designers could drop static motes, view signal ranges, and it will also show the position of each visitor.

Object properties – by clicking on any object on floor plan you should be able to edit its properties, for example by clicking on empty floor plan you should be able to add new floor plan, enable grid and snap to grid, etc., or by clicking on any mote you should see its ID or change the color, etc.

Zoom function – Zoom in and out function for floor plan window

Registered motes status – List of active motes in system



Picture 4: Application GUI Layout

The exact design of server part and mote communication protocol hasn't been discussed yet, and there are still some unresolved issues like when will be the visitor detected, what if the visitor just passes by exhibits? The solution for that problem might be the definition of some time period in which visitor must stay in the same mote detection area, or set up of "mote doors", so when visitor enters the room through that virtual door content streaming should begin. (**NOTE:** for exact definition multimedia streaming content and timing should be discussed further more) Also server part has to implement a mechanism to stop (shut down) static motes after the working time, and start them again in the morning.

The proposed programming technology and language is .NET and C# with Infragistics controls for Main Application part and nesC for MOTE programming.

1.2 Interface for Personnel

Personnel interface should be very similar to Administrative Mote controlling part of application, for example personnel should not be able to edit the position of static motes or floor plan, but only to view it. Personnel will have a tab for adding and registering visitors, and also view all the live streams for control purpose in case something goes wrong. Personnel should be also able to view the position of visitors on floor plan in real time.

1.3 PDA application and multimedia content streaming

Having PDA devices enables visitors to view the multimedia content. Multimedia content can be separated in two groups; first group would be audio and video, and second one plain text information with pictures. There are three delivery solutions for video and audio: direct download, streaming technology and pre-stored content on PDAs.

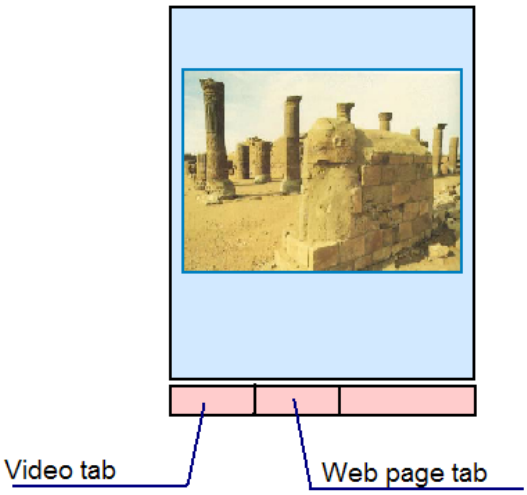
Direct download is the simplest solution, unfortunately has issues that makes this technology arguable for Interactive museum usage. Using direct download, every time user change its position new video material has to be downloaded to PDA, which takes some time, the time gap is not a biggest problem, the main problem rises when user change its location quickly enough to always download something but never be able to watch it (because of time lag) thus overloading the server. In situation with 100+ visitors this could be a serious shortcoming.

Pre-stored content on PDAs are another proposed solution, when multimedia content is directly stored on PDA device server just have to pass information what should be played and not the played material itself. This method most certainly won't overload the server but it is not flexible at all, because on every exhibit museum staff needs to download multimedia materials on PDAs. It is a bad solution if there are many PDAs and multimedia content takes too much space.

Streaming technology may be the optimal solution. Video is streamed not downloaded and it is stored only on server. The two main problems with previously explained solutions are solved. Unfortunately the streaming solution has its own shortcomings. First is the complexity of implementation and the second one is the bandwidth. There are to types of streaming: continuous streaming and on-demand streaming. In continuous streaming (constant loop of one video on same channel) visitor will join the stream at the point that most certainly won't be the beginning of video. For a two minute video if user joins the stream in the middle of it he or she will have to wait 1 minute to view the video from beginning. Another type of stream is the on-demand which solves the issue of random video entry point. On-demand streaming requires constant bandwidth, if video is encoded in 100kbit/s for 100 users server bandwidth should be 10+ Mbit/s.
Size of streamed video stored on server is calculated from this formula:

$$\text{size(MB)} = \left(\text{length(s)} \cdot \text{bit rate}\left(\frac{\text{kbit}}{\text{s}}\right)\right) \cdot \frac{1000 \text{ bit}}{1 \text{ kbit}} \cdot \frac{1 \text{ byte}}{8 \text{ bits}} \cdot \frac{1 \text{ MB}}{1,048,576 \text{ bytes}}$$

Plain text information with pictures can be provided through web page adapted for viewing on Small screen devices such as PDAs.



Picture 5: PPC application GUI Layout

PPC application should consist of two tabs one for video/audio streaming and another for web page viewing. PDA will be wirelessly connected to network (802.11g) and according to detected mote ID in particular exhibit room, server should tell the PPC application which streaming content must be displayed. (**NOTE:** Exact protocol has not yet been discussed)

The proposed programming technology and language is .NET compact framework and C#.

Appendix: ***(Few words from the author of the document)*** The easiest solution for providing the streaming on Windows Mobile 5 platform is Windows Media streaming. Windows Media player for PPC even has ActiveX component that can be used in standalone application. The only problem is that .NET CF doesn't come with ActiveX support but there is a workaround. Further information is available on links listed below:

- http://msdn2.microsoft.com/en-us/library/aa454909.aspx
- http://www.microsoft.com/downloads/details.aspx?familyid=46ba698a-c00d-4b90-9177-460854f1b57c&displaylang=en

1.4 Web page generation component

Since every move of visitor has been tracked and written to database the mechanism for generating customized web pages should exist. The visitor web page should contain information of visited and not visited exhibits and related information (including streaming multimedia, historical information, pictures, etc.) The details haven't been discussed yet.

The proposed programming technology and language is .NET and C# (ASP.NET)

3. Further topics

It is evident that the project cannot be done without a good database design. Database should store information about static mote layout. Each registered user and their visited spots, informations about the exhibit layout (links between certain static mote and related streaming content), etc.
Another necessary step that must be done is test information generation (setting up a small test environment - exhibit in a lab, taking videos and pictures...) and also there should be a simulator for mote communication for testing purposes.

All of the above must be discussed further on.