# 52. IWK

Internationales Wissenschaftliches Kolloquium

International Scientific Colloquium

**PROCCEDINGS** | **10 - 13 September 2007**

## FACULTY OF
## COMPUTER SCIENCE AND AUTOMATION

# COMPUTER SCIENCE MEETS AUTOMATION

## VOLUME II




TECHNISCHE UNIVERSITÄT
ILMENAU

**Bibliografische Information der Deutschen Bibliothek**
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

**ISBN 978-3-939473-17-6**

Impressum

| | |
|---|---|
| Herausgeber: | Der Rektor der Technischen Universität Ilmenau<br>Univ.-Prof. Dr. rer. nat. habil. Peter Scharff |
| Redaktion: | Referat Marketing und Studentische Angelegenheiten<br>Kongressorganisation<br>Andrea Schneider<br>Tel.: +49 3677 69-2520<br>Fax: +49 3677 69-1743<br>e-mail: kongressorganisation@tu-ilmenau.de |
| Redaktionsschluss: | Juli 2007 |
| Verlag: | Technische Universität Ilmenau/Universitätsbibliothek<br>Universitätsverlag Ilmenau<br>Postfach 10 05 65<br>98684 Ilmenau<br>www.tu-ilmenau.de/universitaetsverlag |
| Herstellung und Auslieferung: | Verlagshaus Monsenstein und Vannerdat OHG<br>Am Hawerkamp 31<br>48155 Münster<br>www.mv-verlag.de |
| Layout Cover: | www.cey-x.de |
| Bezugsmöglichkeiten: | Universitätsbibliothek der TU Ilmenau<br>Tel.: +49 3677 69-4615<br>Fax: +49 3677 69-4602 |

## Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
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Mark Ritzmann

# Scientific visualisation on mobile devices with limited resources

## ABSTRACT

The article focusses on a base, that makes scientific visualisation possible on mobile devices with limited resources. The aim is to gain access to databases, produce a visual representation of selected content and display it to a viewer on a limited capability device. Hardware addressed are low end appliances, that have a limited radio network connection at their disposal, however in its CPU speed, graphics performance and display size as well as available RAM are restricted (cell phones and PDA). To enable the production and representation of interpretable[1][1] graphics in this sphere, existing technologies like web applications and the platform Java 2 Micro Edition are combined [2]. The introduced architecture permits mobile access to data and the visualisation on thin-clients (web front end) as well as limited capability devices using MIDP. Especially the J2ME APIs were looked at considering their applicability in the context. Applications arise in geoinformatics, civil engineering, mechanical engineering and medicine.

## MOTIVATION

In addition to the application as a communication instrument mobile devices are used increasingly as a "computer system on the Internet ". The mobile phone allows access independent of place to data and accessibility with the functionality of computers. Applications for mobile devices profit from these qualities and open thus perspectives for available software (e.g. e-mail, PC-synchronized organizer). Nevertheless, the integration of mobile devices as front end of a client server architecture develops in the scenario of the visualisation difficultly. Because of limited resources (memory, arithmetic achievement and graphics system) and missing programming interfaces (APIs) for this platform the solutions which still allow the access to the data bases and a high-quality visualisation must be found.

[1] The viewer should understand the context of the real world from the graphic and connections and parameters in the value distribution can infer.

## 1 J2ME and the MID-Profile - Client side

The platform Java2 Micro edition addresses by configurations (CDC, CLDC) and profiles (MIDP, PDAP) different device sections and devices. Optional packages serve as an interface for functionalities specific for devices and/or specific for manufacturer. Covered by the aimed application scenario J2ME APIs offers for the network communication (generic connection framework) as well as APIs for the realisation of user interfaces and the issue of graphic representations (LCDUI, GameAPI). Nevertheless, the available graphic system is limited to 2D graphic, above all, game development (collision recognition, use of spirits etc.) and it is usually not hardware accelerated. Support of the optional package "mobile 3D-API" or NVIDIA-GPUs on mobile phones don't yet belong to the standard. Therefore, necessary visualisation technologies like vertex, transformation, rasterization, texturing, lighting etc. are not available at all or very much limited.

## 2 System architecture

The use of an application server is necessary for different reasons:

- Mobile devices do not support the communication with databases and require a protocol converter / adaptation layer
- The unsafe network connections of mobile devices (reason for the name "limited connected device") could lead to interrupted connections and the release of requested resources in the back end must be guaranteed by an additional layer.
- Because of the possible client count the resource requirement with the database server would raise needlessly and might become not manageable.
- The direct connection of the client with the database would require in case of changes in the database scheme an adaptation of the client software.
- MIDP 1 capable devices are limited to have at least http-protocol support.

Figure 1 shows the favoured three tier architecture. The application server is realised as a servlet based web application. Servlets can serve as a data source for contents in HTML pages (text, images, SVG objects) and are also localizable by mobile devices [6]. The implementation of the application server as a J2SE component allows the access to available APIs and standard extensions of the platform: database access JDBC [4]; compression and conversion of graphics - ImageIO; visualisation OpenGL [7] or Java3D. To enhance the communication for MIDP 2 compliant devices, a socket connection can be used for a more interactive protocol than stateless http. Selected images and measureing data are temporary stored server sided too, to avoid unnecessary calculations an database request with repeated or parallel request.

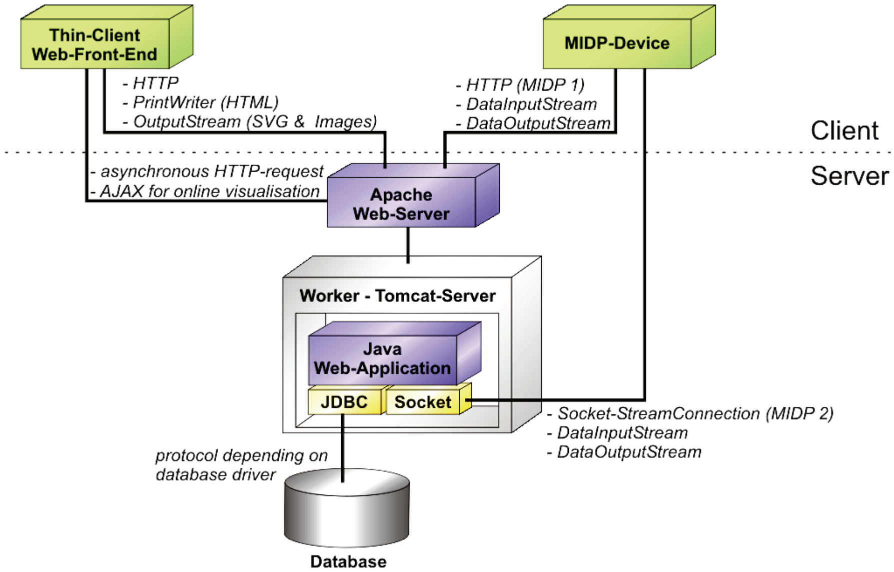


Figure 1: system model and protocols in the tree tier architecture

## 2.1 Web-Front-End

The visualisation within the scope of a web application occurs in form of interactive SVG [5], static images or their integration for compositions with SVG.

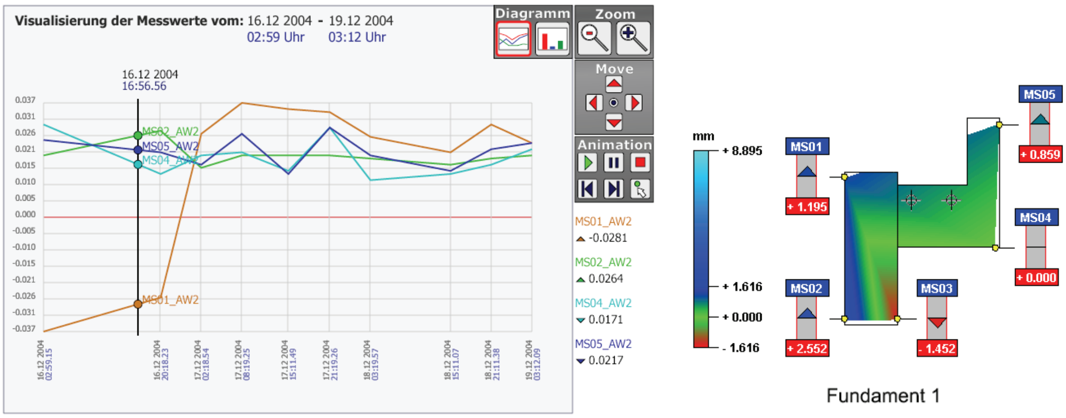


Figure 2: visualisation as interactive SVG (left) and embedded static png-image (right)

For SVG visualisation merely the required records are encoded as variables in Java-Script. The production of the final representation occurs through Java-Script client-sided. Therefore the data volume is reduced for the transfer and the desired visualisation technique can be changed by the user, without renewed communication with the server, interactively. This addresses mobile Internet access through a mobiles radio network. For online visualisation of frequently changing data AJAX/JavaScript is used to retrieve new data using asynchronous http-requests. This results in periodically refreshes without loading the whole page and non cacheable embedded elements. The response are either measuring data which are directly used to update the SVG-DOM or picture references which are updated in the web page or SVG. Examples of interactions are animations of temporal course (linear interpolation), change of representation, observing of certain measuring times or the overlay of contour plots and ground plans on demand. The production of the static graphics is based on off-screen rendering using a 2D/3D graphic systems. Varied visualisation technologies are applicable through this. The contents of the frame buffer is grabbed and it is converted in a web-compliant format. As source for the picture data (img-tag, src-attribute) the rendering servlets URL is defined. 3D Graphic systems offer functions which would not be possible in SVG graphics or partly only by costly pre-calculations [9]. Besides, the transfer as an image limits the requirements for the client component and forms the interface for the visualisation on mobile devices with even more constrained resources.

### 2.2 Visualisation on mobile devices with limited resources

Devices capable of J2ME dispose of a Microbrowser for the representation of HTML pages (required for over the air user initiated provisioning too). Because of the low display resolution, the supported media formats and the application model (if necessary service about keypad) the realisation requirements differ from their one thin client web application. For the data selection a combination of dialogues and graphics (LCDUI) is offered [3]. The visualisation occurs in form of server-sided generated graphics. Color reduction, scaling and tiling etc. can be done by filter (-chains) of the web application. The client is reduced to view images.

#### 2.2.1 Applicability of the MIDP-API to the scientific visualisation

**LCDUI:** Static background images like in games or the composition of the scene from returning tiles resisting in the MIDlet-suite (TiledLayer) are not related within the scope of the visualisation. The wanted scenario is insufficiently supported by the available APIs. Depending on the OEM's implementation, large images, or even with a resolution greater than the display, will not be supported. Therefore and for efficient scrolling large images must be divided into tiles. To allow the scroll about the partial pictures, several graphics must exist locally. The segmenting and the reconstruction were examined at the example by CAD graphics, academic visualisation and real pictures of the resolution 512x512. The derived parametres can be used for load balancing in the distributed system and optimisation of the representation quality on the client. Depending on contents and tile size the essential parameters which should be introduced here only at an example could be derived: Data volumes by transfer of the whole image:

CAD: JPEG 1x2 = ~78MB - JPEG 5125x512 = ~28KB - Break Even Point: 106x133
CAD: RGBZIP: 1x2 = ~15 MB – RGBZIP 512x512 = ~9KB – Break Even Point: 86x86
Among the rest, additional ones were looked the RGB difference in the whole image and the number of the individual parts (relevant for the function and efficiency of the cache algorithms, as well as load of the KVM). Statements about the footprint in memory can be derived only partly, because this strongly depends on the respective implementation. The use of the SVG-API was not considered, because this description would be suitable merely with CAD data. The topical MIDlet allows the smooth scrolling about large graphics and missing tiles are reloaded asynchronously (viewport first then borders).

**Generic Connection Framework:** As a protocol for the communication with the application server are available http (MIDP 1) and socket (MIDP 2). In the http protocol the restriction exists in the strict request response model. The client requests here for a number of partial pictures. For the realisation of Session-Tracking the Session-ID is added as a header to the response and encoded in inquiries of the client accordingly [8]. Sockets allow here a higher delicacy in the communication. After every transfer the connection can be used once more and topically required data if necessary be requested. This is especially relevant if the user during the transfer scrolls and earlier required partial pictures lie, in the meantime, beyond the viewport.

**Record Store Management System:** The application uses different caches for interactive visualisation. Sprite cache contains the tiles of the viewport and border areas. Memory-cache and RMS-cache are realised as a ring buffer more determinably of steady size. Not required tiles of the viewport, are filed at first in the RAM and later if necessary and available in the RMS with increasing latency while object reincarnation. The objects or parts of it (compressed image-data with tile localisation in RMS) reside alternatively either in one of the memories or must be loaded on the network. In the RMS entries of the same size whose contents are substituted cyclically are put on. This is conditioned by the fact that, deleted RMS records space is not always released immediately. Replaceing the contents solves the problem. The maximum image size in bytes is determined by the server for all tiles and defines the maximum size of a record. The divergence between maximum size and average was likewise examined in the test.

## 3 Application Example

The introduced system model orientates itself by a concrete application problem from the area of the geoinformatics. The company "Position Control GmbH" works among other things by order of the "Deutsche Steinkohle AG" and supervises buildings in regions of topical or former conveyor sites. For this sensors are placed in objects which determine periodically transformations and temperatures and feed this into a database.

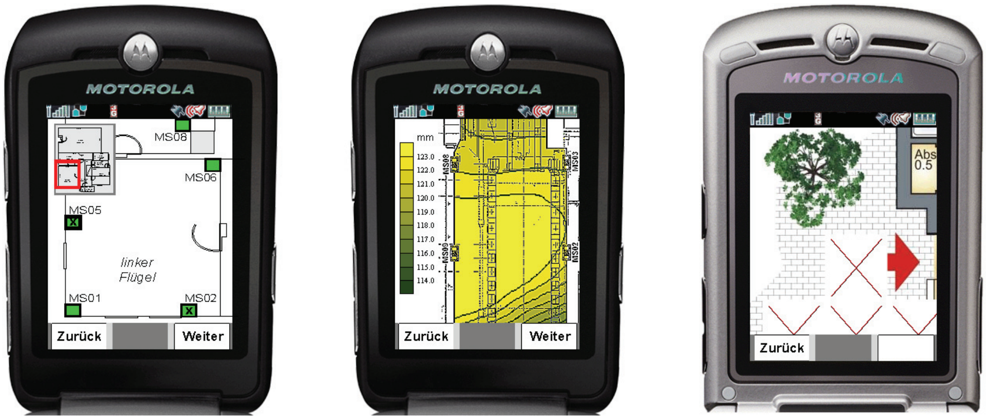


Figure 3: Possible operating surface for the MIDP application. Representation of a server-sided processed CAD file of the supervised object and overlapping with sprites for the eligible measuring points (on the left). Visualisation by contour plots (in the center) and a view with missing tiles marked as cross (on the right).

The engineers can carry out by evaluation of the data an appraisal and initiate countermeasures in border-valued situations. To be able to analyze on site the topical data, the integration of mobile devices was necessary.

## 4 Results

Both attempts of distributed visualisation vary in their interactivity. Especially the pre-calculation of graphics reduces the client requirements and allows such an interpretation of the data also on mobile devices with limited resources. However, the implementiation of applicable graphic representation and interaction models requires huge expenditure and is only partly supported by the available APIs.

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Author:

Dipl.-Inform. (FH) Mark Ritzmann
FH-Schmalkalden, Am Schwimmbad
98574 Schmalkalden
Phone: 03683 688-4216
Fax: 03683 688-4297
E-mail: m.ritzmann@fh-sm.de