



Enabling Grids for E-science

## Managing Healthcare and Medical Information Utilizing Cloud Computing

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- **Concept Introduction**
- **Cloud Computing & Healthcare**
- **Related Work**
- **Proposed Platform**
- **Framework Architecture**
- **Case Study**
- **Conclusions**

- **Vast amount of medical and biological data (medical & biological devices, sensors, contextual data, etc.)**
- **Demand for:**
  - The availability of e-health applications and medical information anywhere
  - Anytime
  - Invisibility of computing
- **Mobile & modern healthcare technologies support:**
  - Telemedicine,
  - Patient & personalized monitoring,
  - Location-based medical services,
  - Emergency response and management,
  - Pervasive access to healthcare information.

- **Requirements for proper realization:**
  - Data storage and management (physical storage & availability issues, maintenance, etc.)
  - Interoperability and availability of heterogeneous resources (heterogeneous data, global access seamlessly)
  - Security and privacy (encryption @ storage & transmission, access control)
  - Unified and ubiquitous access (platforms, infrastructures, interfaces)

- **Potential solution: Cloud Computing + electronic Healthcare Solutions:**
  - Access shared resources
  - Common infrastructure in a ubiquitous and pervasive manner
- **In this context:**
  - Pervasive healthcare information management system for mobile devices utilizing:
    - Cloud Computing
    - Android Operating System

- **Cloud Computing:**
  - Convenient, on-demand network access to a shared group of configurable computing resources (e.g., networks, servers, storage, applications, and services)
  - Rapidly provisioned and released with minimal management effort or service provider interaction
  
- **Major Characteristics:**
  - On-demand self-service (unilaterally obtain access to computing capabilities)
  - Broad network access
  - Resource pooling
  - Rapid elasticity
  - Measured Service

- **Major Benefits:**
  - Agility & re-usability
  - Cost (startup infrastructure, centralization of infrastructure in locations with lower costs, etc..)
  - Multi-tenancy (sharing of resources and costs across a large pool of users)
  - Reliability
  - Security
  - Sustainability & Resources utilization
  - Maintenance
- **Examples of existing Cloud Services:**
  - iCloud, DropBox, GoGrid, Amazon AWS

- **Mobile & Virtual Environments in Healthcare**

- Virtual health records and mobile access:

- *Sabine Koch, Maria Hägglund, Isabella Scandurra, Dennis Moström, “Towards a virtual health record for mobile home care of elderly citizens”, presented in MEDINFO 2004, Amsterdam, 2004.*
    - *Kumar A., Purandare A., Chen J., Meacham A., and Subramanian, L. 2009. ELMR: lightweight mobile health records. In Proceedings of the 35th SIGMOD international Conference on Management of Data (Providence, Rhode Island, USA, June 29 - July 02, 2009).*
    - *Alvin T.S. Chan, “WWW\_smart card: towards a mobile health care management system”, International Journal of Medical Informatics 57 (2000) 127–137.*

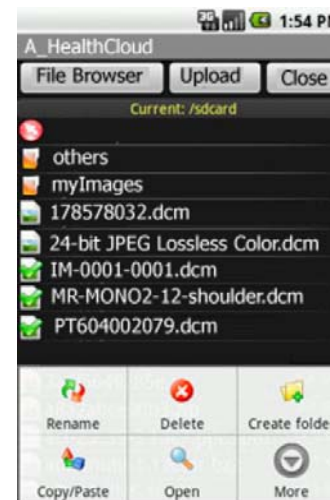
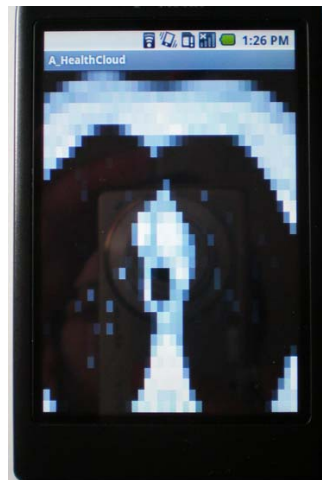
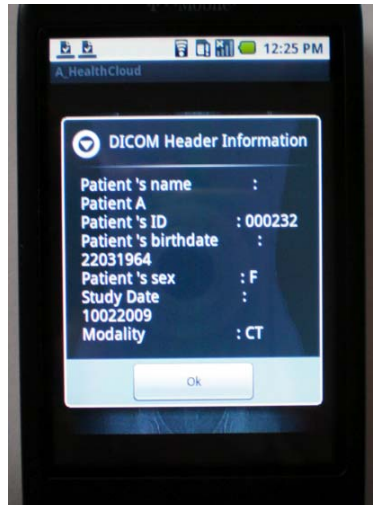
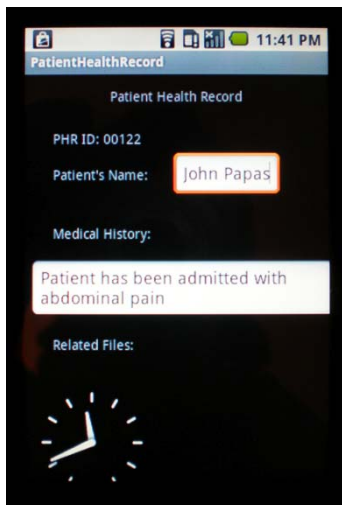


- **Mobile & Virtual Environments in Healthcare**
  - MAPID: Distributed information platform allowing wide-area health information exchange based on mobile agents
    - *Chuan Jun Su, “Mobile multi-agent based, distributed information platform (MADIP) for wide-area e-health monitoring”, Computers in Industry 59 (2008) 55–68.*
- **Issues:**
  - Based on proprietary architectures and communication schemes
  - Require the deployment of specific software components
  - Focus mostly on delivering data to healthcare applications
  - Do not address: management and interoperability

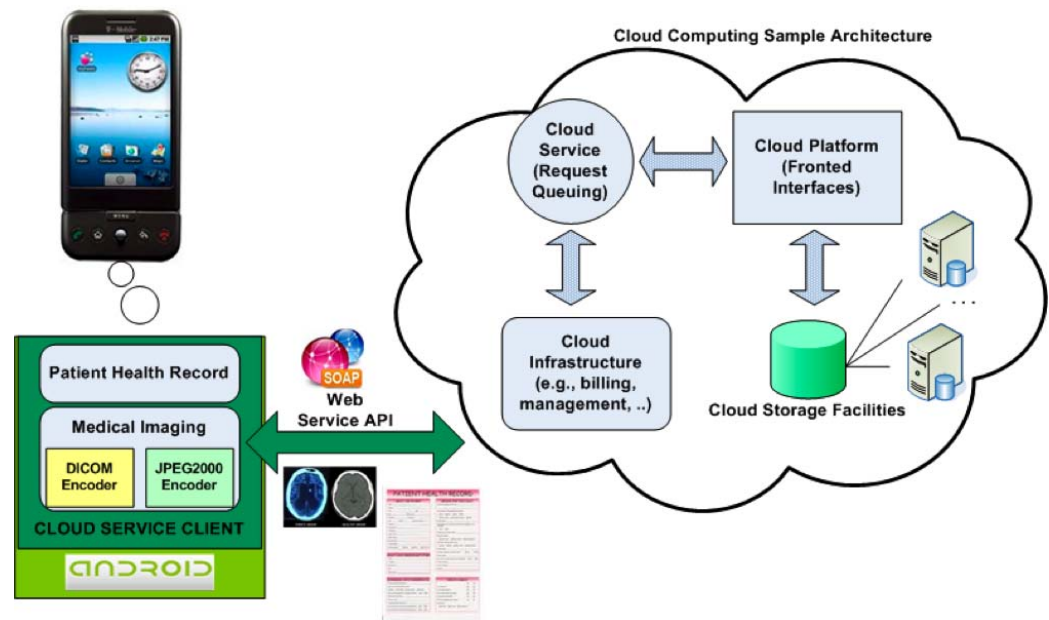
- **Main purpose:**
  - Provide medical experts and patients with a mobile user interface for managing healthcare information
  - Storing, querying and retrieving medical images (e.g., CT scans, MRIs, US etc.), patient health records and patient-related medical data (e.g., biosignals)
  - Data may reside at a distributed Cloud Storage facility, initially uploaded/stored by medical personnel through a Hospital Information System
  - Communication and data exchange has to be performed through non-proprietary, open and interoperable communication standards

- **@HealthCloud utilizing Web Services connectivity and Android OS supports the following functionality:**
  - Seamless connection to Cloud Computing storage utilizing Web Services and the REST API
  - Patient Health Record Management
  - DICOM image viewing support
  - JPEG2000 viewing support
  - Image annotation support
  - Proper user authentication and data encryption

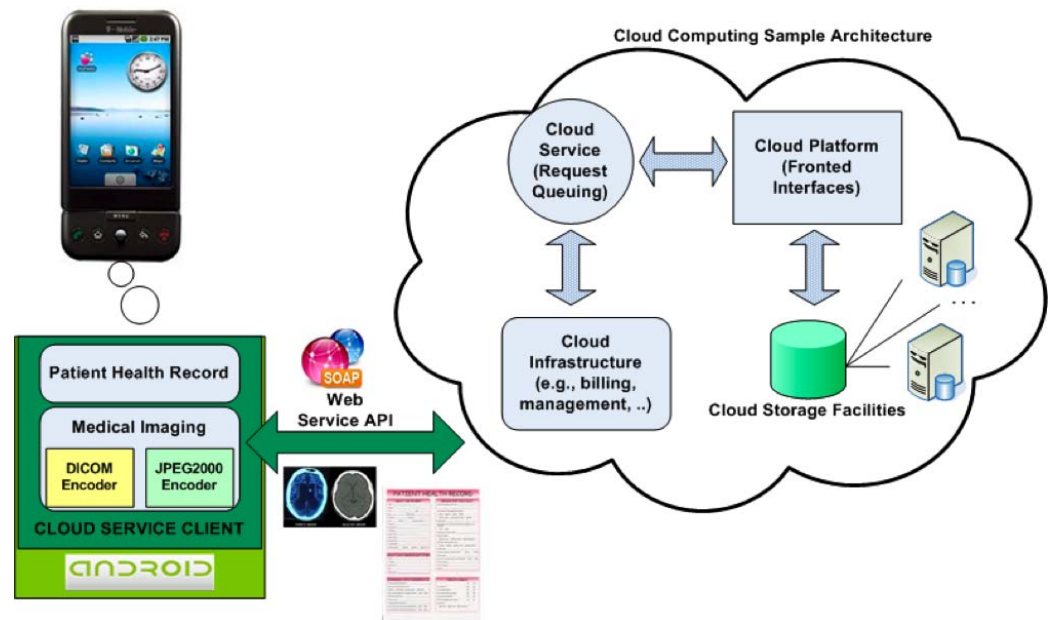
- @HealthCloud:



- Major Components:
  - Platform front-end interface
  - Cloud Storage Facilities
  - Cloud Platform Interface
  - Cloud Infrastructure Module



- **Major Components:**
  - The Patient Health Record application
  - The Medical Imaging module
  - Cloud Service Client
  - Android OS



- **Utilizing Amazon Cloud Computing Service**
  - Amazon Simple Storage Service (S3)
  - Commercial well established service
  - Interoperable web interfaces for managing data
  - Ability to create custom applications
  - Suitable for healthcare applications -> HIPAA compliant:
    - privacy rule regulations include standards regarding the encryption of all patient-related data in transmission and in storage.

- **Technical Details:**
  - Android OS 1.6
  - Implemented on Google (HTC) G1
  
- **Initial Evaluation:**
  - A number of medical images of different modalities (MR, CT, PET, OT and Ultrasound)
  - WLAN and a commercial 3G Network

Image Type (encoding)	File Size (MB)	Time (secs)	
		3G Network	WLAN Network
OT (24-bit JPEG2000 Lossless Color)	6.8	42.532	7.894
CT (Uncompressed)	0.528	4.023	2.382
CT (JPEG2000)	0.102	1.223	0.892
MR (JPEG Lossless)	0.721	9.738	3.894
PET (JPEG2000 Lossy)	0.037	0.923	0.793
Ultrasound (sequence of 10 images, JPEG2000 Lossless)	0.487	3.892	3.251



- **Sharing of medical information resources -> key factor for successful adoption of healthcare systems**
- **Cloud Computing can provide means for:**
  - Better data storage and management
  - Interoperability
  - Availability
  - Maintenance
  - Security
- **@HealthCloud:**
  - Prototype implementation of a mobile healthcare information management system based on Cloud Computing and Android OS
  - Future work: Improve security + real scenario evaluation