Design Issues for Electronics Health Records Using Cloud Computing Technologies

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Topics of Discussion
- An Introduction to HealthIT and EHR
- Definitions: EHR (Electronic Health Record), EMR, Cloud Computing
- Previous Research in EHR Interoperability and Health Information System Integration
- Cloud-Based EHR System Architecture Design Issues
- A Windows Azure-Based EHR Case Study
- Conclusion
**Introduction**

The integration of EHR in IT infrastructures supporting organizations enable

- Improved access and recording of patient data
- Enhanced ability to make improved decisions,
- Improved quality and
- Reduced errors in patient care.

Research has shown that the healthcare industry is plagued by

- Rapidly increasing costs,
- Poor quality of service,
- Lack of integration of patient care, and
- Lack of information access to Electronic Health Records (EHR).

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**World-Wide Healthcare Spending and GDP Ratio** [1]

[Graph showing healthcare expenditure as a percentage of GDP for various countries, with labels indicating countries such as US, Switzerland, and others, along with GDP per USD.]
Definitions

- **EHR (Electronics Health Record)**, http://www.himss.org/library/ehr/
  - The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting.
  - EHR includes patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports.
  - The EHR automates and streamlines the clinician’s workflow.
  - The EHR has the ability to generate a complete record of a clinical patient encounter - as well as supporting other care-related activities directly or indirectly via interface - including evidence-based decision support, quality management, and outcomes reporting.

An Example EHR [2]
# EMRs and EHRs [3]

<table>
<thead>
<tr>
<th>EMR (Electronic Medical Record)</th>
<th>EHR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td></td>
</tr>
<tr>
<td>The legal record of clinical services for a patient within a Care Delivery Organization (CDO)</td>
<td>A subset of EMR from one or more CDOs where the patient received clinical services</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td></td>
</tr>
<tr>
<td>Owned by the CDO</td>
<td>Owned by patient or stakeholder</td>
</tr>
<tr>
<td><strong>Consumer &amp; Usage</strong></td>
<td></td>
</tr>
<tr>
<td>Supplied by enterprise vendors and installed by hospitals, health systems, clinics, etc</td>
<td>Run are community, state, or regional health related organizations</td>
</tr>
</tbody>
</table>

## EMRs and EHRs [3] (cont.)

<table>
<thead>
<tr>
<th>EMR (Electronic Medical Record)</th>
<th>EHR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right of Patient</strong></td>
<td></td>
</tr>
<tr>
<td>Patients can gain access to some EMR info authorized by the EMR owners</td>
<td>Provided with interactive access as well as the ability to append information</td>
</tr>
<tr>
<td><strong>Interoperability with other CDOs</strong></td>
<td></td>
</tr>
<tr>
<td>Each EMR contains only the patient's info encountered in a single CDO.</td>
<td>Sharing information among multiple CDOs, connected by National Health Information Network (NHIN)</td>
</tr>
</tbody>
</table>
The emergence of cloud computing services provides users with
- flexible access,
- large storage capability and
- low costs,
However, securing EHRs in cloud is a major challenge. Several security properties need to be satisfied, such as
- data privacy
- fine-grained access control
- and scalable access between different clouds

Options of EHR in Cloud
- Applications in the cloud (Software as a Service – SaaS).
- Infrastructure in the cloud (Infrastructure as a Service – IaaS)
- Platforms in the cloud (Platform as a service – PaaS)
Cloud-based EHR System Architecture Design and Issues

- EHR System Life Cycle
  - Requirements, Analysis, Design, Testing, and Installation

- Storage Requirements

- Communication & Networking Bandwidth Requirements

- Fault Tolerance and System Availability

- Security and Privacy

- Government Laws and Regulations

System Design: Patient-Provider Interaction
SOA-based Design [4]

System Design: EHR Service Candidates (SOA-approach) [4]

- EHR Access Services
- EHR Update Services
- EHR Process Orchestration Services
- EHR Business Rules Services


- InsertPatient
- GetPatient
- UpdatePatient
**Cloud-Based HER Design**

- SaaS-based EHR
- IaaS-based EHR
  - Cloud Storage of EHR
- PaaS-based EHR

**Cloud-Based EHR vs. Client/Server Design Consideration**

<table>
<thead>
<tr>
<th>Features</th>
<th>Infrastructure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>EHR in a Cloud</td>
<td>Client/Server</td>
</tr>
<tr>
<td>1. Location of system code and execution</td>
<td>Remote, usually at vendor’s premise</td>
</tr>
<tr>
<td>2. Control of System Data</td>
<td>Less control</td>
</tr>
<tr>
<td>3. System migration and/or scalability in future, assuming the same vendor is used</td>
<td>Easier</td>
</tr>
</tbody>
</table>
### Cloud-Based EHR vs. Client/Server Design Consideration (cont.)

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>EHR in a Cloud</strong></td>
</tr>
<tr>
<td>4. Security (for small clinics with limited tech support &amp; computer resources)</td>
<td>More security</td>
</tr>
<tr>
<td>5. Hardware Requirements</td>
<td>Fewer</td>
</tr>
<tr>
<td>6. Response time</td>
<td>Dependent upon Internet service, provider, network provisioning, and HER vendors</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>EHR in a Cloud</strong></td>
</tr>
<tr>
<td>7. Remote access via Internet</td>
<td>Easy</td>
</tr>
<tr>
<td>8. Maintenance</td>
<td>Easier</td>
</tr>
<tr>
<td>9. Data synchronization for clinic with multiple offices</td>
<td>Easier</td>
</tr>
</tbody>
</table>
Cloud-Based EHR vs. Client/Server Design Consideration (cont.)

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<tr>
<td></td>
<td>EHR in a Cloud</td>
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<tr>
<td>10. Data backup and disaster recovery</td>
<td>Easies and cheaper</td>
</tr>
<tr>
<td>11. Initial cost</td>
<td>Lower</td>
</tr>
<tr>
<td>12. Total life-cycle cost (3-5 years)</td>
<td>Lower</td>
</tr>
</tbody>
</table>

Previous Research: EHR Data Interoperability and Interoperable Platforms) [4][5]

- Platform independent data formatting and architectural
- Enables automatic data exchange between care sits
- The needs of Standards
  - Data structure, Messaging and Communication, Architecture, Clinical Documents, Semantic Content, Security, Business requirements, etc
### EHR Standards

- **HL7**, [www.hl7.org](http://www.hl7.org)
- **EHRCom**
- **DICOM (Digital Imaging and Communications in Medicine)**, [http://medical.nema.org/](http://medical.nema.org/)

<table>
<thead>
<tr>
<th></th>
<th>Visualization</th>
<th>Format</th>
<th>Signing</th>
<th>Popularity</th>
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<tr>
<td>HL7 CDA</td>
<td>+</td>
<td>XML</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>EHR Com</td>
<td>-</td>
<td>XML</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>DICOM SR</td>
<td>-</td>
<td>Binary</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
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### Cloud-based EHR System Architecture

**Design and Issues**

- **EHR System Life Cycle**
  - Requirements, Analysis, Design, Testing, and Installation

- **Storage Requirements**
  - Privacy & Security
  - Achieving HIPAA regulatory compliance through data centers with bank-level security and high-level encryption methods
Cloud-based EHR System Architecture
Design and Issues

- EHR System Life Cycle
- Storage Requirements
- Communication & Networking Bandwidth Requirements (Factors to Consider)
  - Number of users
  - User locations
  - Real-time transactions
  - Hardware
  - Storage technology

Cloud-based EHR System Architecture
Design and Issues

- Fault Tolerance and System Availability
  - System Availability = MTTF/(MTTF + MTTR)
    - MTTF – Mean Time to Failure; MTTR – Mean Time to Repair
  - Unplanned hardware, software, network components failures
  - Planned shutdown
  - Partial vs. total failure
  - Cloud system tolerance to system failures
    - Hot Standby Server Clusters
    - Active Takeover Clusters
    - Failover Cluster
  - Recovery Schemes: Backward recovery, Roll Back, Forward Recovery
Cloud-based EHR System Architecture
Design and Issues

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- Government Laws and Regulations
## Key Tasks

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<th>EHR Role</th>
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<tr>
<td><strong>EMR system functionality</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Key Tasks</strong></td>
<td><strong>EHR Role</strong></td>
</tr>
<tr>
<td><strong>Review Patient History</strong></td>
<td>Memory, Computation, Decision Support, Collaboration</td>
</tr>
<tr>
<td>Displays available history and demographics</td>
<td>Provides Contextual view of overall patient health</td>
</tr>
<tr>
<td><strong>Conduct Patient assessment</strong></td>
<td>Prompt for required information, Compute Statistics (BMI etc.)</td>
</tr>
<tr>
<td><strong>Determine Clinical Decision</strong></td>
<td>Relate assessment to patient history, Display trends, reference ranges</td>
</tr>
<tr>
<td><strong>Develop treatment plan</strong></td>
<td>Standards of care, care plans, evidence based guidelines</td>
</tr>
<tr>
<td><strong>Order Additional Services</strong></td>
<td>Review previous services/results, Determine appropriate provider/ location</td>
</tr>
<tr>
<td><strong>Prescribe Medications</strong></td>
<td>Medications history, allergies, formulary, Dose Calculation</td>
</tr>
<tr>
<td><strong>Document Visit</strong></td>
<td>Diagnosis and treatment codes, Prompts/automatic population</td>
</tr>
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**A Case Study of an Windows Azure-based EHR with Android Mobile Apps**

![Diagram of Windows Azure-based EHR with Android Mobile Apps]
Windows Azure Platform

- Filtering Routers
- Firewalls
- Cryptographic Protection of Messages
- Monitoring
- Network Segmentation

Practice Fusion (free web based HER hosted on Cloud)
Conclusion

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