Singapore’s National Electronic Health Record Architecture

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Outline

- Overview of Singapore Healthcare and the National EHR
- 6 Observations of the National EHR Architecture project
- An Implementor’s Perspective of Architecture
Singapore: a small country…..

- 4.59 million people on 707.1 sq km (6,489/km²)

- Ethnically diverse:
  - Chinese: 75 per cent
  - Malays: 14 per cent
  - Indians: 9 per cent
  - Others: 2 per cent

- 35,000+ healthcare providers

- 11,580 hospital beds

- 429,744 hospital admissions (2007)

- Public sector out-patient visits (2007)
  - Specialist Outpatient Clinics 3,687,910
  - A&E 752,122
  - Polyclinics 3,797,953
Patients have freedom of choice to choose any providers of care in various sectors.

**Primary Healthcare**
- 17 Polyclinics (20%)
- Private GP Clinics (80%)

**Secondary & Tertiary Specialist Care**
- 7 Restructured Hospitals & 6 specialty centers (80%)
- 16 Private Hospitals (20%)

**Step-down & Long Term Care**
- Voluntary welfare Organizations (70%)
- Private Healthcare Organizations (30%)

Public sector
Private sector
People sector
New Directions: Systems of Integrated Care

How do we integrate care “horizontally” across systems?

- Information Technology
- Manpower
- Platforms for Coordination
Taking the Next Step
(Minister Staff Mtg – April 2008)

1. Singapore requires a national integrated electronic health information system based on a common enterprise architecture, data standards and privacy and security guidelines

2. A shared electronic health record (EHR) can be delivered by 2010

3. Broad stakeholder engagement is needed. The EHR is not an IT project but a business and clinical transformation project.

4. Governance and accountability is necessary to align strategic intent with implementation.
   - National strategy and implementation plan
   - Funding mechanisms to encourage consistent, coordinated and continuous investment in health IT
   - Skilled resource capacity

5. Measuring of success of the national EHR with regards to health care quality, safety, and productivity
National EHR Architecture (NEHRA)

- Given the **federated** nature of our healthcare ecosystem, an Enterprise Architecture approach is needed to arrive at a **consensus** on the National EHR Architecture.

- Proposed to Minister
  - Form **core group of Enterprise Architects**
  - Analyse **current IT state**
  - Develop early **principles to guide IT project towards participation in NEHR**
Multiple opinions on what the NEHR should be

Major **clinical IT projects ongoing** with high impact to NEHR, e.g. CPOE, EMR upgrade, PAS upgrade

Ongoing IT projects are **constantly evolving**
- October 2008 – interviewed an IT system project manager to capture Current State
- January 2009 – same project manager informed us that information is inaccurate during Goal State Review!

Hence, aggressive timeline needed to **focus efforts**
- 80-20, just enough – just in time
- Pushed **parallel tracks** – Clinical Use Cases and IT Architecture
#1 – Aggressive timeline to focus efforts

Accelerated from 5 June at project start to 20 March!
#2 – Clinically driven

- 35 Clinical & non-clinical stakeholders interviewed to develop the NEHRA Vision

- Clinical Advisory Group
  - Chaired by CIO MOHH, comprising Clinical leadership from institutions and Ministry of Health
  - NEHRA presented to CAG at key milestones
  - Members invited to detailed NEHRA workshops

- Clinical Taskforces developed detailed Use Cases
  - Summary Care Record & Continuity of Care
  - Medication Management & Computerized Physician Order Entry (CPOE)
  - Secondary Data-Use Taskforce
  - Diagnostics Taskforce
#2 – Clinically driven

- **11 Clinical Use Cases** developed
  - General Practitioner/ Polyclinic visit
  - Emergency Dept Encounter & Disposition
  - Outpatient Specialist Care
  - Discharge Summary
  - Chronic Disease Management
  - Wellness and Prevention
  - Evaluation of a National Integrated Health Screening Programme For Diabetes Mellitus
  - Immunisation Management
  - Ordering Tests & Viewing Results
  - Medication Management
  - Clinical Audit
Example Clinical Use Case -- Chronic Disease Management

Darker boxes indicate new steps proposed

New clinical docs for EHR

Each swim-lane represents reference actor, actual process may differ across actors

Many parties involved!
Guided by Architectural Principles…

- **Portal based** – with additional toolsets to support targeted clinical capabilities
- **Iterative and phased implementation** – targeting key clinical capabilities
- **Role based** – to support clinical access requirements in a secure and authorized way
- **Loosely coupled** – to support flexibility and extensibility over time
- **‘Hybrid’** – central repository summary health care information, access to detailed reports / images via record locator service
- **Service oriented based approach** – integration layer to support interoperability and provision of registry and identification services
- **Leverage existing systems and investments** where possible
#4 – Objective Architecture Trade-offs

- 13 Architectural Options were discussed using objective assessment of the tradeoffs
  - Clinician Access Channels
  - EHR Enabled Capabilities
  - Event Notification
  - EHR Configuration
  - Information Model and Standards
  - Data Exchange
  - EHR/PHR Data Exchange
  - Patient, Clinician and Facility Identification
  - Access Management
  - User Authentication
  - Encryption and Signatures
  - Leveraging Existing Systems
  - Business Intelligence Enablement
## #4 – Objective Architecture Trade-offs

### Clinician Access Channels

<table>
<thead>
<tr>
<th>ANALYSIS CONSIDERATIONS</th>
<th>OPTIONS</th>
<th>1. EHR accessed via EMR</th>
<th>2. EHR accessed via a portal</th>
<th>3. EHR is a separate application</th>
<th>4. EMR is accessed via EHR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meet Requirements and Principles</strong></td>
<td>Ability to view patient health information</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Ability to view health information aligned with workflow and processes</td>
<td>Modify work processes to utilise EHR</td>
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<tr>
<td>Supports clinical workflow, and decision making</td>
<td>Modify work processes to utilise EHR</td>
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<tr>
<td><strong>Stakeholder Acceptance</strong></td>
<td>Use existing applications</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Ease of use</td>
<td>New application with access via a portal</td>
<td></td>
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<tr>
<td>Minimize disruption</td>
<td>New application with new access mechanisms</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Technical Feasibility</strong></td>
<td>Complex development with dependencies on vendors</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Leverages existing capabilities</td>
<td>Shares access channels</td>
<td></td>
<td></td>
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<tr>
<td>Complexity of development</td>
<td>Can utilise an available vendor product</td>
<td></td>
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</tr>
<tr>
<td><strong>Manage Impact and Effort</strong></td>
<td>Requires greater effort and has higher costs b/c of integration</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Integration</td>
<td>Less integration, but requires application screens</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Development</td>
<td>No integration needed, but requires application screens</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Maintenance</td>
<td>Require greater effort and have higher costs b/c of integration</td>
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</table>

### KEY MESSAGES
- Option 1 is the most aligned with clinician workflow and best promotes clinician adoption and usage, but it will have extensive dependencies on the EMR vendors and their willingness/ability to integrate EHR data with their views and/or application; Option 2 is needed for clinicians without an EMR, and may also be used by those with an EMR depending on their preference.
- All options require change management for the adoption of the EHR into clinical practice, regardless of whether clinician access is via EMR, through an existing portal or via a separate EHR tool.
#5 – Leverage existing systems and initiatives (IT example)

- **Intuitiveness** is required for adoption
- **Co-exist in short-term**
  - EMRX – non-standards based document exchange
  - CMIS – allergies & med alerts
  - NIR – child immunisations
- **Retire in longer-term**
- **Evolutionary approach** minimises risk
  - Continue to use existing systems
  - Gradually adopt EHR usage, rather than big-bang cut-over
  - Loose-coupling – less dependency on institutional IT change plans
#5 – Leverage existing systems and initiatives (business example)

- **Existing programmes** exist to manage business relationships with hospital partners
  - Delivery-on-Target with GPs
  - Agency for Integrated Care with step-down care facilities

- **EHR** leverages these programmes for e-referral
  - Leverage existing/planned IT projects
  - Dovetail into existing clinical transformation and business process change initiatives

- Similar approach for order entry, medication management

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**Option: Capability that Resides with the Provider**

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**Diagram Description:**

- Healthcare Providers (Hospitals, GPs, ILTC)
- EHR
- Referral Processing Systems
  - DOT
  - AIC
  - Others...
- Work Queue
  - Referral Document
- Referral Document Locator (i.e., link to Referral Document)
- Other...
- EHR Record Locators to access Referral Document(s)
#6 Keep things simple

- **Access control management** can easily become complex
  - Legitimate users cannot be pre-determined
    - patient gets moved around in an institution
    - care team formation is very dynamic
  - Difficult to establish end of patient-institution relationship,
    - chronic disease patient who regularly visits a specialist
  - Legitimate healthcare institutions cannot be pre-determined,
    - patient has choice of provider, and emergency situations
  - Patient explicit consent is operationally difficult to manage

- Architecture options analysis can inform pragmatic policy

- Singapore is adopting an **implied-consent, opt-out, role-based** model for access control
  - Additional access controls may be implemented for specific use cases where required and practical
Architecture Highlights

- **Business Architecture**
  - 23 Business capabilities identified
    - e.g. Manage Patient Demographics, Review Summary Record, Reconcile Medications, and Create Discharge Summary

- **Application Architecture**
  - 70 planned and existing IT systems characterised, across 5 different types of care settings
  - Include systems in the Ministry of Health for regulatory systems, and Health Promotion Board for population health systems

- **Information Architecture**
  - 700 existing and new information exchange flows were identified

- **Service Architecture**
  - 18 Core EHR services and 7 other services identified
EHR – Conceptual View

EHR Summary Record
- Name
- NRIC No.
- Date of Birth
- Gender
- Primary Care Provider
- Care Coordinator
- Allergies
- Immunisations
- Diagnoses
- Current Medications
- Investigations
- Procedures
- Recent Events
- Recent Referrals
- Care Plan

Shared Services / Functionality
- DA / ADR Module
- Medications Reconciliation
- Care Team Details
- Referral Processing
- Immunisation
- Problem List Reconciliation
- Shared Care Plan
- Personal Health Record (PHR)

Business Intelligence
- Data Warehouse
- National Scorecard
- Programme Scorecard

Event Summary, Referral & Screening Documents
- GP
  Event Summary
- SOC
  Event Summary
- Referral to SOC
- SOC Referral to GP
- ED
  Event Summary
- Inpatient
  Disch. Summ.
- Community Hosp Disch. Summ.
- AIC / ILTC
  Referral
- School Screening

Detailed Reports / Images
- Laboratory Reports
- Radiology Reports / Images
- Procedure Reports

Drill Down

Applications that are not a part of the EHR solution, but will be integrated with the EHR
### New end-user screens/functionalities
- Summary Care Record
- Detailed Documents
- Reconciliation
- Basic CDS
- Referral
- Shared Care Plan
- etc.

### EHR Services
- **Summary Care Record**
- **Reconciliation**
- **Basic Clinical Decision Support**
- **Affiliated Services**
- **eReferral/Shared Care Plan**

### Common Business Services
- **Patient**
- **Clinician**
- **Facility**
- **Record Locator**
- **Data Transformation**
- **Data Retrieval**
- **Consent**
- **Terminology**

### Technical Services
- **Enterprise Service Bus**
- **Access/Authentication**
- **Audit Logging**
- **Monitoring**
- **etc.**

### Data Provision Interface
- **Provider Gateway**

### Data
- **EMRs**
- **Repositories (CMIS, NDIR, etc.)**
- **Virtual EHR Database (RLS)**
- **Summary Care Record**
- **Master Indices**
- **Reconciliations (Med, Diagnosis, etc.)**
- **Documents (Event Summaries, Referral, etc.)**
SingHealth
Singapore’s Eastern Healthcare Group

- 3 Hospitals
- 5 National Specialty Centres
- 9 Polyclinics
- 3,300 Beds
- 42 Specialties
- 2,000 Doctors
- 1.9 m Specialist Outpatient visits
- 1.6 m Polyclinic visits
- 186,473 Admissions
- 76,615 Inpatient Surgeries
- 110,857 Day Surgeries

... & Traditional Chinese Medicine

* Affiliate medical school co-located on Outram Campus
NHG & NUHS
Singapore’s Western Healthcare Group

3 Acute Hospitals
1 Mental Institute/Hospital
7 National Specialty Centres
9 Polyclinics
5,060 Beds
13,765 Professional Staff
341,260 AE Attendance
2.27m Polyclinic visits
141,423 Inpatient Episodes
1.7m SOC Attendance
76,615 Inpatient Surgeries
Date of Incorporation: July 23rd 2008
Parent Company: MOH Holdings Pte Ltd
IT Professionals Strength: ~660

Vision - To be the trusted technology partner in healthcare
Enterprise Architecture Objectives

- **Consolidation of Systems & Architecture**
- **Accountability & Ownership of Data / Information**
- **Govern IT Implementation across cluster**
- **Harmonize Processes and Workflow to achieve Integrated Care**
- **Integrated Information Systems**
- **Architecture Standards to support Business Objectives**
Business Reference Model
( Business Area - Level 0 )

- Healthcare Services Business Area
- Education Business Area
- Research Business Area

Enabling Business Area
Conceptual Application Model vs BRM

(Level 0)

Direct Care
Supportive Care

Education

Research

Corporate & Administration
Information Infrastructure
Conceptual Application Model (Level 1)

Direct Care
- DC 1: Care Management
- DC 2: Clinical Decision Support
- DC 3: Operations Management

Supportive Care
- SC 1: Clinical Support
- SC 2: Measurement, Analysis, Research and Reports
- SC 3: Patient Management

Corporate & Administration
- CA 1: Human Resource
- CA 2: Medical and Nursing
- CA 3: Communication
- CA 4: Material Management
- CA 5: Finance

Information Infrastructure
- IN 1: Security
- IN 2: Health Record Information & Management
- IN 3: Standard Terminologies & Terminology Services
- IN 4: Standards-based Interoperability
- IN 5: Registry & Directory Services
- IN 6: Business Rules & Workflow Management

Educational & Research
- ED 1: Learning Management
- RS 1: Experimental Research
- RS 2: Clinical Research

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Conceptual Application Model (Level 2)

Direct Care
- Care Management
  - DC 1.1 Record Management
  - DC 1.2 Manage Patient History
- Clinical Decision Support
  - DC 2.1 Manage Health Information
- Operations Management
  - DC 3.1 Clinical Workflow Testing

Supportive Care
- Clinical Support
  - SC 1.1 Registry Notification
  - SC 1.2 Drug Management Support
  - SC 1.3 Provider Information
- Measurement, Analysis, Research & Reports
  - SC 2.1 Measurement, Monitoring & Analysis
  - SC 2.2 Report Generation
  - SC 2.3 Data-Identified Data Request Management
- Patient Management & Accounting
  - SC 3.1 Encounter/Episode of Care Management
  - SC 3.2 Information Access for Supplemental Use
  - SC 3.3 Administrative Transaction Processing
  - SC 3.4 Manage Practitioner/Patient Relationship
  - SC 3.5 Subject to Subject Relationship
  - SC 3.6 Acuity and Severity
  - SC 3.7 Supporting Function Maintenance

Corporate & Administration
- Human Resource
  - CA 1.1 Manpower Planning
  - CA 1.2 Performance Mgt
- Medical and Nursing
  - CA 2.1 Medical Administration
  - CA 2.2 Nursing Administration
- Communication
  - CA 3.1 External Communication
  - CA 3.2 Internal Communication
- Material Management
  - CA 4.1 Procurement
  - CA 4.2 Inventory Management
- Finance
  - CA 5.1 Account Receivables
  - CA 5.2 Account Payables
  - CA 5.3 General Ledger
  - CA 5.6 Fixed Assets

Information Infrastructure
- Security
  - IN 1.1 Entity Authentication
  - IN 1.2 Entity Authorization
  - IN 1.3 Entity Access Controls
  - IN 1.4 Patient Access Management
  - IN 1.5 Non-Repudiation
  - IN 1.6 Secure Data Exchange
  - IN 1.7 Secure Data Routing
  - IN 1.8 Information Authorization
  - IN 1.9 Patient Privacy and Confidentiality
- Health Record Information and Management
  - IN 2.1 Data Retention, Availability & Destruction
  - IN 2.2 Auditable Records
  - IN 2.3 Synchronization
  - IN 2.4 Extraction of Health Record Information
  - IN 2.5 Store and Manage Health Record Information
- Standard Terminologies & Terminology Services
  - IN 4.1 Standard Terminologies & Terminology Models
  - IN 4.2 Maintenance & Versioning of Standard Terminologies
  - IN 4.3 Terminology Mapping
- Standards-based Interoperability
  - IN 5.1 Interchange Standards
  - IN 5.2 Interchange Standards Versioning and Maintenance
  - IN 5.3 Standards-based Application Integration
  - IN 5.4 Interchange Agreements

Education
- Learning Management
  - ED 1.1 Training
  - ED 1.2 Assessment

Research
- Experimental Research
  - RE 1.1 Animal Information Database
  - RE 1.2 Experimental Project
  - RE 1.3 Inventory and Control
  - RE 1.4 Funding and Finance
  - RE 1.5 Announcements, Publications, Awards & Conferences

MOH Holdings Pte Ltd
Existing Data Centers Setup

Diagram showing the setup of existing data centers connected through different networks and service providers.
Possible End-State after Consolidation

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Budget Announcement 2009: Singapore’s EHR

“MOHH is also developing an electronic health records system accessible to authorised medical practitioners at our hospitals and polyclinics, and eventually extending to the community care sector. It will allow for more effective treatment of patients who may receive a spectrum of healthcare services from different providers. We will be spending about $200 million to get this project launched over the next two years and will be among the first in the world to implement such a system nation-wide.”

Note: S$200 million ~ USD$139 million
The Promise of the EHR

- Well-managed chronic illness
- Improved access to care
- Fewer adverse drug events
- Better prescribing practices
- Reduction in duplicate or unnecessary tests
- Reduced wait times
- Increased patient participation in care

A young boy waiting at A&E, Tan Tock Seng Hospital
Thank You

MOH Holdings
www.mohh.com.sg