Cloud Computing for Research and Health Care

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Outlines

- NIST Definition of Cloud Computing
- Cloud for Biomedical Research
- Cloud for Health Care

NIST Definition v.15

- **Cloud computing** is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Five Characteristics of Cloud

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured Service

"The kind of service that dry-lab biomedical researchers have always wanted…"

Other Terms related to Cloud

- Service Model
  - Cloud Software as a Service (SaaS)
  - Cloud Platform as a Service (PaaS)
  - Cloud Infrastructure as a Service (IaaS)
- Deployment Model
  - Private cloud
  - Community cloud
  - Public cloud
  - Hybrid cloud

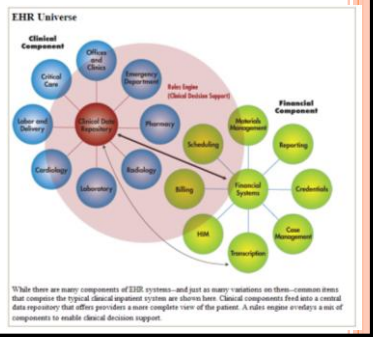
Cloud-based Clinical Data Repository (CDR) for Research

CDR (**Clinical Data Repository**)

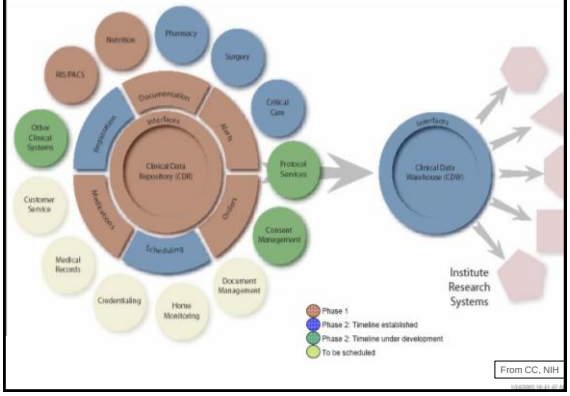
- A real-time database that consolidates data from a variety of clinical sources to present a unified view of a single patient or a single visit
- Typical data types
  - Clinical laboratory test results, patient demographics
  - Pharmacy information, radiology reports and images
  - Pathology reports, hospital admission, ICD codes, discharge summaries, progress notes…etc.
- The ROCDR (Research-Oriented CDR) Project in Taiwan
  - Taipei Medical University, National Yang-Ming University, Wan Fang Hospital, Shen-Ho Hospital, Tri-service Hospital…etc.

Clinical Data Repository (CDR)

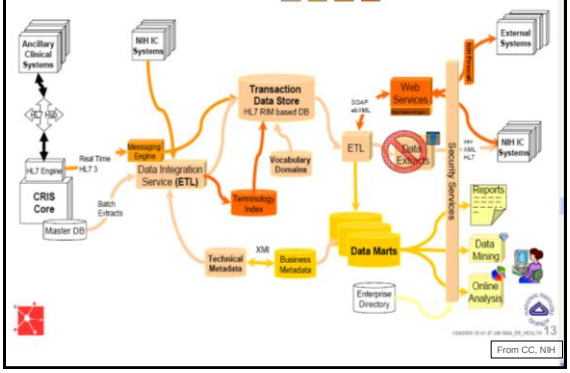
- Often a backend of Electronic Health Record (EHR) for efficient patient-level data access
- High potential for clinical research



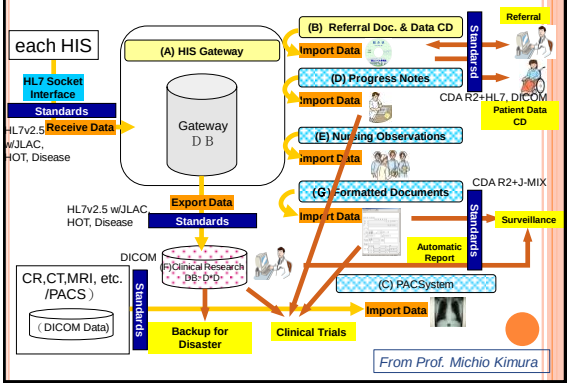
CRIS Conceptual Architecture



Implementation Strategy Release Progression

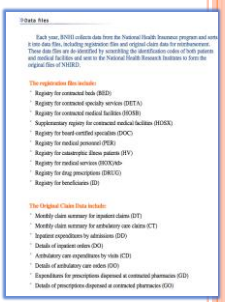


JAPAN'S EMR SHARING FOR RESEARCH PURPOSE



NHIRDB in Taiwan

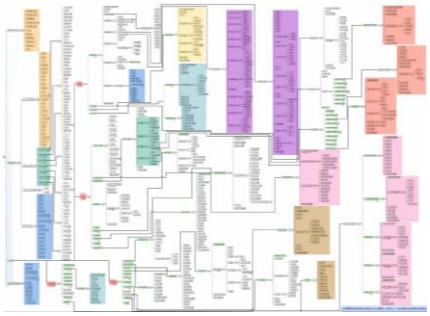
- NHIRDB (National Health Insurance Research Database)
  - 12 years of de-identified claim database for 23 million people
  - Cohort DB (Five 1-million people groups for 13 years)
  - Disease-specific DB (16 disease groups)
  - Random sample DB (outpatient 1/500, inpatient 1/20)
  - generates >100 research papers a year



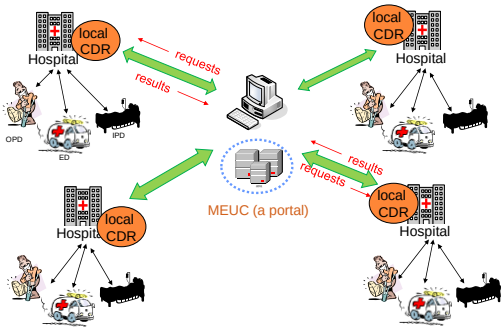
ROCDR in Taiwan

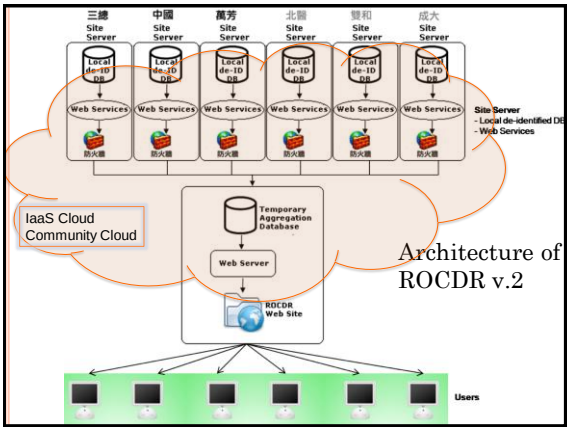
- A cloud-based (IaaS) environment for research CDR
- Compare favorably to Claim Database
  - No claim data bias
  - Including non-covered drugs, procedures
  - Outcome data: lab and exam results/reports
- Four Medical Centers
  - 7,500 beds
  - 8.1 million outpatient/year
  - 300,000 inpatient and 350,000 ER visits/year

Very Complex Data Structure of EHR



Architecture of ROCDR v.1

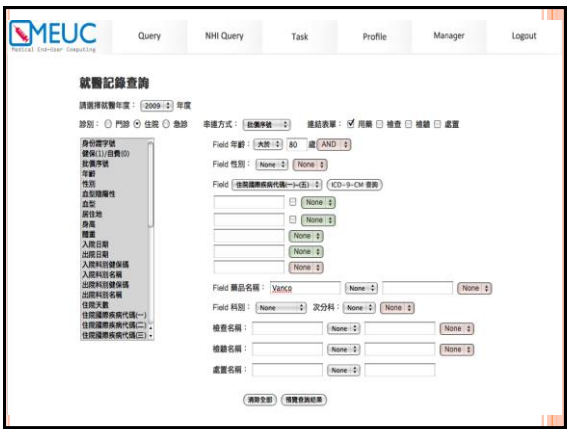




Architecture of ROCDR v.2

Challenges

- Much more than just de-identification and aggregation
  - Bin-size issue
  - Incomplete de-identification
- ELSI and IRB issues
- Highly complex data structures with natural language (free text) requires state-of-the-art algorithms to ETL (Extract-Transform-Load) and de-ID.
- Computational technologies to support ELSI requirements



出院國際疾病代碼_5	醫師	用藥科別健保碼	用藥/院內科別名稱	藥品項目健保碼	藥物商品名	藥物學名	用藥劑型	實際給藥量	每次用量	用藥頻率	藥品單位	給藥途徑
	A003	07	神經外科	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	20	20	2	Q12H	Vial	IVD
	A003	07	神經外科	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	8	8	2	Q12H	Vial	IVD
	A003	07	神經外科	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	28	28	2	Q12H	Vial	IVD
	A003	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	0	0	1	QW26	Vial	IVD
	A003	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	2	2	STAT	Vial	IVD
	A003	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	2	1	QW26	Vial	IVD
	A003	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	1	1	QW26	Vial	IVD
	A003	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	12	7	1	QW14	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	0	0	1	QOD	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	0	0	1	QOD	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	0	0	1	QOD	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	1	1	STAT	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	1	1	1	STAT	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	2	1	QOD	Vial	IVD
	A005	02	內科部	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	1	1	1	QW14	Vial	IVD
	A005	AD	腎臟科	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	2	1	1	STAT	Vial	IVD
	A005	14	腫瘤科	B017742277	VANCOMYCIN 500MG/VIAL	VANCOMYCIN	0	0	1	QW14	Vial	IVD

MEUC Medical End-user Computing

Query | NHI Query | Task | Profile | Manager | Logout

(資料完成查詢時間依查詢結果筆數多寡及伺服器負載進異，敬請耐心等待)

查詢式	查詢開始時間	查詢結束時間	工作進度	目前符合筆數	檔案下載	刪除
2009年門診,用藥,檢體 介於 25 ~ 65 歲 女性 國際疾病碼 = 250.0 或 401 或 401.0 或 401.1 或 250.00	2010-07-31 19:40:00	2010-08-13 06:26:01	100 %	124,585,535	10% 檔案下載 Full Data 等待審核	刪除
2009年門診,用藥,檢體 大於 65 歲 女性 國際疾病碼 = 250.0 或 250.00 或 401 或 401.0 或 250.1	2010-07-31 19:40:00	2010-08-13 06:26:01	100 %	144,713,051	10% 檔案下載 Full Data 等待審核	刪除
2008年住院,用藥,檢體 大於 65 歲 女性 國際疾病碼 = 250.0 或 250.00 或 401 或 401.0 或 401.1 查詢藥品名稱：%INSULIN%	2010-07-31 19:40:00	2010-07-31 23:10:35	100 %	2,166,424	10% 檔案下載 Full Data 等待審核	刪除
2009年住院 大於 歲 不分男女 國際疾病碼 = 250%或 401%	2010-08-02 09:59:37	2010-08-02 10:01:27	100 %	4,756	10% 檔案下載 Full Data 等待審核	刪除
2009年住院,用藥,檢體 大於 65 歲					10% 檔案下載	

Challenges

- ELSI and privacy issues
  - IRB or no IRB or a Joint IRB
  - More complex with more partners
- Lack of data standard for EMR data
  - caBIG, caDSR (Cancer Data Standards Registry and Repository) for hosting and managing metadata)
- Scale and complexity of EHR
- High demand of computational resource to maintain multiparty private computation (shared results without sharing data)
- Not RCT clinical trials (but much cheaper)

Strength of ROCDR

- Scrutinized by the strictest ELSI committee
- Attended by very different hospital groups
  - Military, veterans, private and public university teaching hospitals
- Scalable naturally as the number of partners grow (Using the Cloud IaaS)
- Easy migration to Public Cloud
- Only accessible collectively, no individual anomaly or pattern

Cloud Computing for Health Care

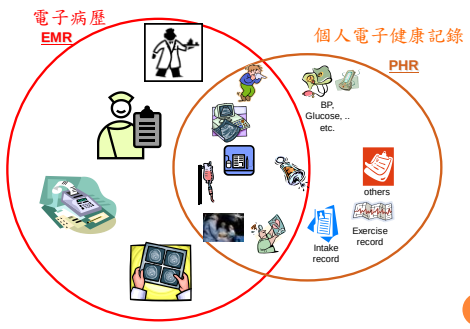
Cloud Computing for Major Hospitals

- Virtualization (IaaS)
  - Cut the maintenance cost in half
  - Much less server room space and much greener
  - More flexibility and portability of services
- Service-Oriented Architecture (SaaS)
  - An overhaul of the basic system architecture
  - Highly flexible and efficient new architecture
  - Fast deployment of new applications
  - Web-friendly

Cloud Computing for Personalized Health Care

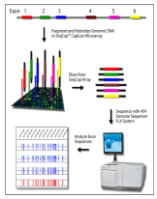
Patient's EHR - PHR

- PHR or ePHR (electronic Personal Health Record) is at the the core of the Next-Generation Health IT
- PHR =
  - Personal part of the EMR from all the providers
  - + self-measured bio-signals
  - + self-entered health related information like family history, exercise, food consumption, food allergies, OTC drugs, cigarette consumption…etc.
- PHR will be the basis of Personalized Healthcare



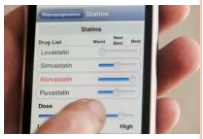
Personalized Medicine

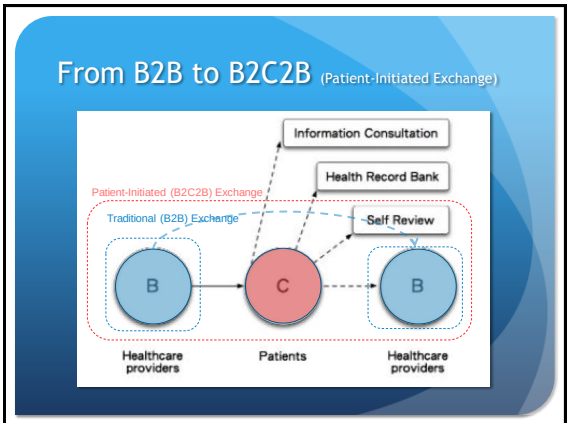
- It is estimated in 2014, a personal Genome can be sequenced under $1,000 USD
- 3 billion DNA and 33K genes
  - → more than 100K proteins
  - → metabolic pathways
  - → all the functions of body

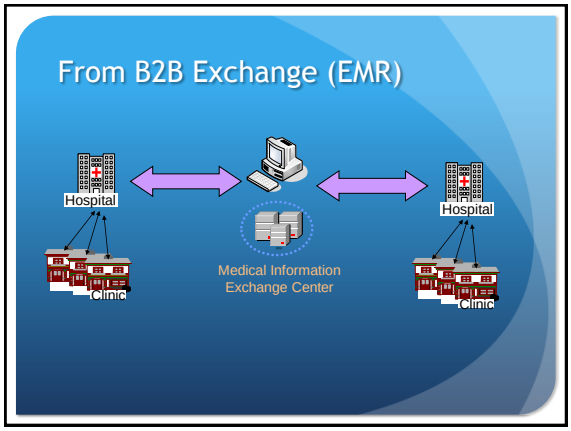


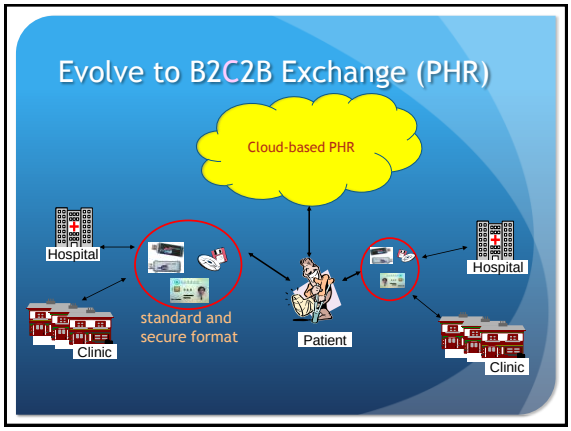
Personalized Medicine (cont.)

- Need a place to
  - store it
  - review it
  - make sense out of it by linking to a person's health information
- PHR will be the ideal place









Cloud Computing for Rural Heath Care

- The lack of IT resource of rural health stations and small hospitals in China (>16,000)
- Pioneered since 2007 by Steve Chan (system architect of Cray-2 supercomputer)
- A new business model for HIT in developing countries and resource-poor areas

Five Characteristics of Cloud

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured Service

"The kind of service that HIT people would always wanted…"

"Who wouldn't?"

Conclusion

- Cloud Computing will change the face of Biomedical Research Data Service
- Cloud Computing, with privacy-enhanced, could change the future of HIT delivery in developing countries and resource-poor areas
- Fits the needs of many healthcare sectors due to flexibility and cost-effectiveness
- Cloud Computing will be a "liberator" for scalability/accessibility limitations