



University Health Network

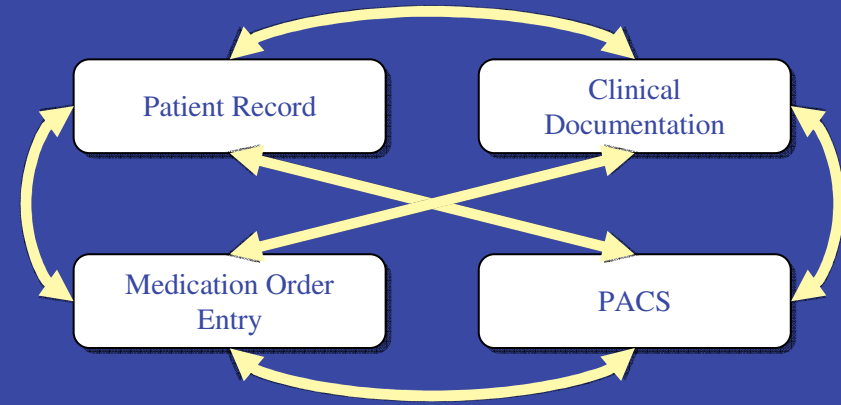
Toronto General Hospital Toronto Western Hospital Princess Margaret Hospital

Challenges and Successes Of Using SNOMED CT In Point-of-Service Clinical Software

Jan. 26, 2010

Introduction

- The vision: The safe, interoperable, adopted Electronic Health Record



- The tools:
 - Data standards (SNOMED CT, HL7, CDA, etc.)
 - Infrastructure and delivery models
 - Advancing technology
- Do we meet clinical needs of electronic healthcare?



Topics of Discussion

- Tangible examples of SNOMED CT in clinical software
- Design and development process
- Challenges
- Building clinical documentation software through multi-disciplinary collaboration and knowledge transfer



Background

- Custom web applications for point-of-care collection of disease/specialty-specific synoptic patient history data
- Dictated clinic notes are traditionally transcribed into the Electronic Patient Record as research-unfriendly text



Background

- SNOMED CT is a good fit:
 - Can handle complexity of clinical scenarios
 - Can accommodate variations in wordings used by clinicians
 - Can encode discrete data for research
- How do we create SNOMED CT-enabled software that meets clinical needs?
 - Barriers to adoption/acceptance: Adapting to clinician culture and habits
 - Finding necessary technical expertise: Real-time search



Projects

- Started working with SNOMED CT in 2005
- Primary incentive:
 - Vocabulary list maintained by standards body - 357,000 clinical concepts
- Secondary incentives:
 - Interoperability with HL7, future mapping to ICD-10CA



Projects

- Multiple implementations:
 - Electronic Discharge Summaries
 - Pharmacy Intervention Tracking
 - Ovarian Cancer Synoptic Operative Note
 - Electronic Ambulatory Documentation



Project: Electronic Discharge Summaries

- Generating in-patient discharge reports for multiple services
- ~500 users: physicians, residents, nurses
- ~34,000 discharge reports created over 4 years



Project: Electronic Discharge Summaries

- Search interface for diagnoses and co-morbidities:

The screenshot displays a web-based search interface for medical diagnoses. On the left, there are two input fields: 'Most responsible diagnosis:' with a light blue button labeled 'Select value...' and 'Other MRDX:' with an empty text box. On the right, a search window is open, titled 'Find value for 'Most responsible diagnosis:'. Inside this window, there is a section 'Items recently selected by you:' which currently shows 'None.'. Below this is a section 'Start a new search:' containing a search bar with the text 'type 1 diabetes' and a 'Search' button. Underneath the search bar, there is a list of search results with checkboxes: 'Diabetes mellitus type 1' and 'Type 1 diabetes mellitus without complication'. A 'Close' button is located at the bottom right of the search window.



Project: Ovarian Cancer Synoptic Operative Note

- Multi-institutional project at UHN, London Health Sciences Centre, Hamilton Health Sciences Centre
- Dropdown/checkbox list options from disease-specific subsets of SNOMED CT terms
- Codes for imaging, diagnoses, procedures, findings, finding locations



Project: Ovarian Cancer Synoptic Operative Note

Executive summary Clinical history Operative note Final details Sign-off note

Pre-op Imaging

Patient had pre-op imaging: Yes No Unknown

- Abdominal CT
- Abdominal ultrasound
- Pelvic CT
- Pelvic MRI
- Trans-vaginal pelvic ultrasound
- Thorax CT
- Chest X-ray

Past Gynecologic Surgeries

- Subtotal hysterectomy
- Total hysterectomy
- Left oophorectomy
- Right oophorectomy



Project: Electronic Ambulatory Documentation



- Generates out-patient consultation and follow-up reports
- Pilot phase for Orthopedics, General surgery, Plastics, Urology
- Presenting complaints, complaint attributes, symptoms, findings, finding locations, finding attributes, procedures, diagnoses, medical conditions, ...
- Subsets + new version of search:



Project: Electronic Ambulatory Documentation

Past Medical Conditions

[Audit trail](#)

Condition	Details
1  Congestive heart failure	Date of diagnosis: <input type="text" value="e.g. Jan 2009"/>  Details: <input type="text"/>

Add medical condition:

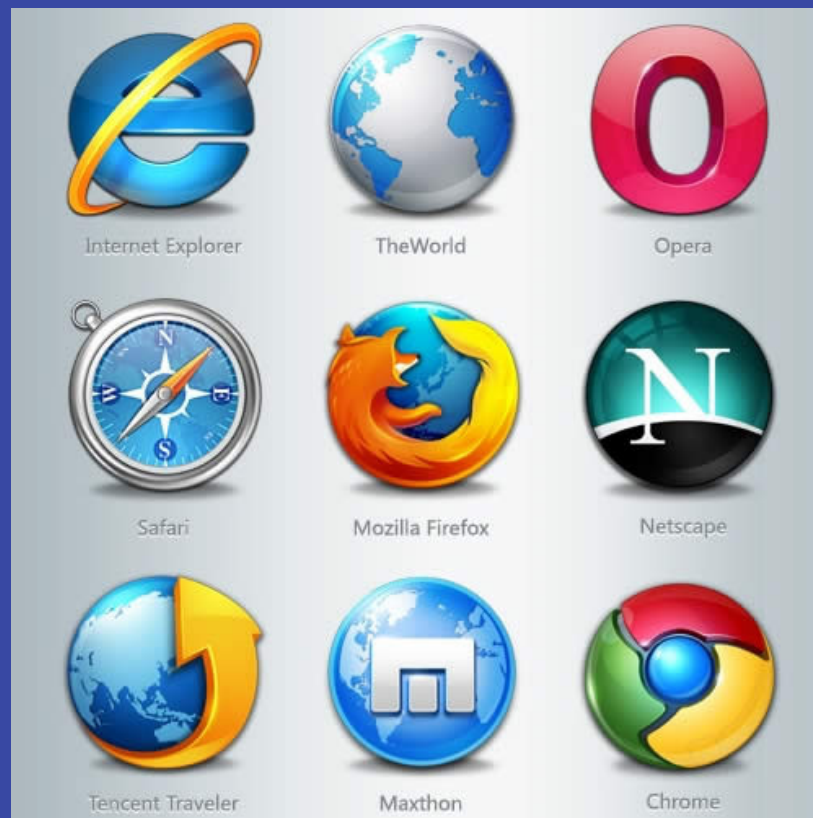
[Add condition](#)

- Diabetes mellitus type 2
- Diabetes mellitus
- Diabetes mellitus type 1
- Brittle diabetes mellitus
- Neonatal diabetes mellitus
- Postpancreatectomy diabetes mellitus
- Protein-deficient diabetes mellitus
- Secondary diabetes mellitus
- Unstable diabetes mellitus
- Gestational diabetes mellitus, class A>2<
- Unstable type 1 diabetes mellitus

Only best matches shown, continue typing for more options



Implementation



Implementation

- We have the vision, we have the tools, yet are slow adopters of new technology
- Impaired clinical workflow?
 - Entering same data into multiple systems
 - Application speed
 - Usability issues
 - Computer accessibility



Implementation: The Challenge

- Health care is a complex system
- Electronic health care poses multivariate challenges
- Understanding the problem is the key to solving it:
 - Scope out problem constraints/requirements
 - Constraints are our friends
 - Solution evolves naturally



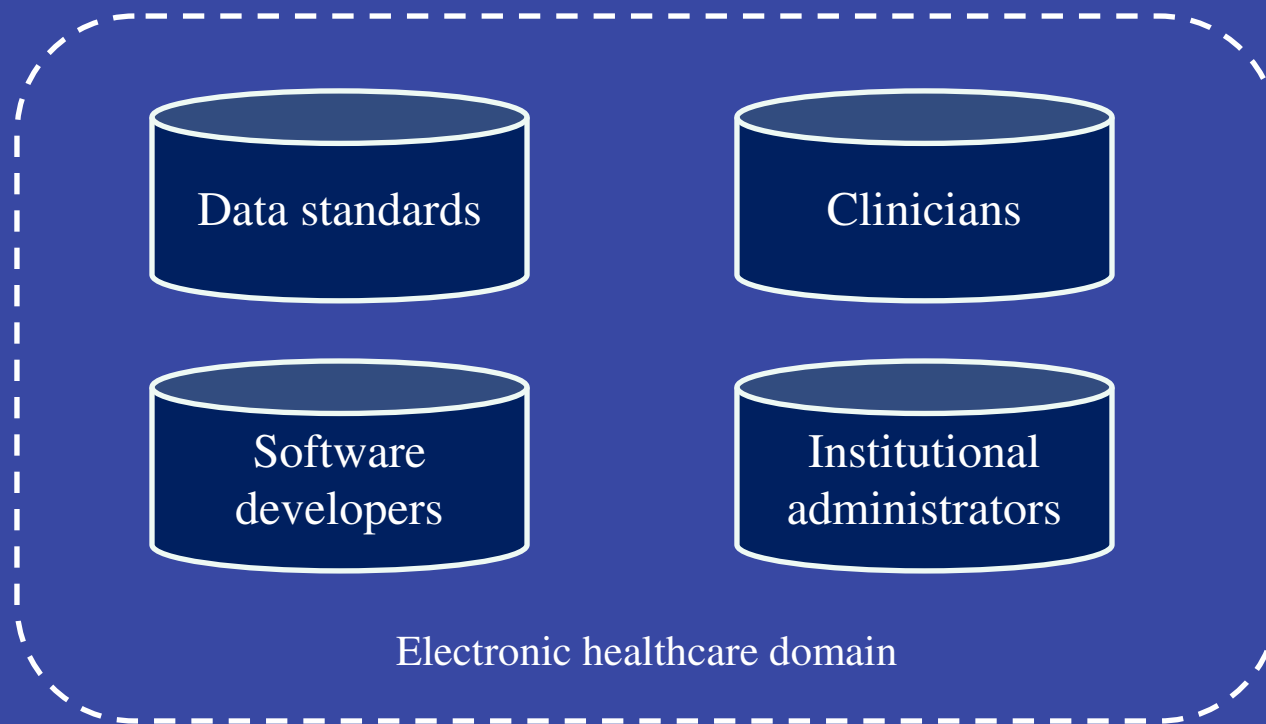
Implementation: Constraints/Requirements

- Cannot interfere with existing clinical practices
- Must make clinical sense
- Must incorporate clinical guidelines for evidence-based healthcare
- Fast performance
- Intuitive GUI
- No redundant processes
- Must provide added value and incentive for adoption
- Accessibility restrictions and experience with computers
- Medico-legal requirements
- Security requirements , user permissions, and audit trails
- Patient privacy and research ethics
- Budget and resources
- Data modeling and database normalization
- Institution's IT infrastructure
- Institutional, provincial, national mandates
- SNOMED CT learning curve
- Data standard initiatives
- And the list goes on...



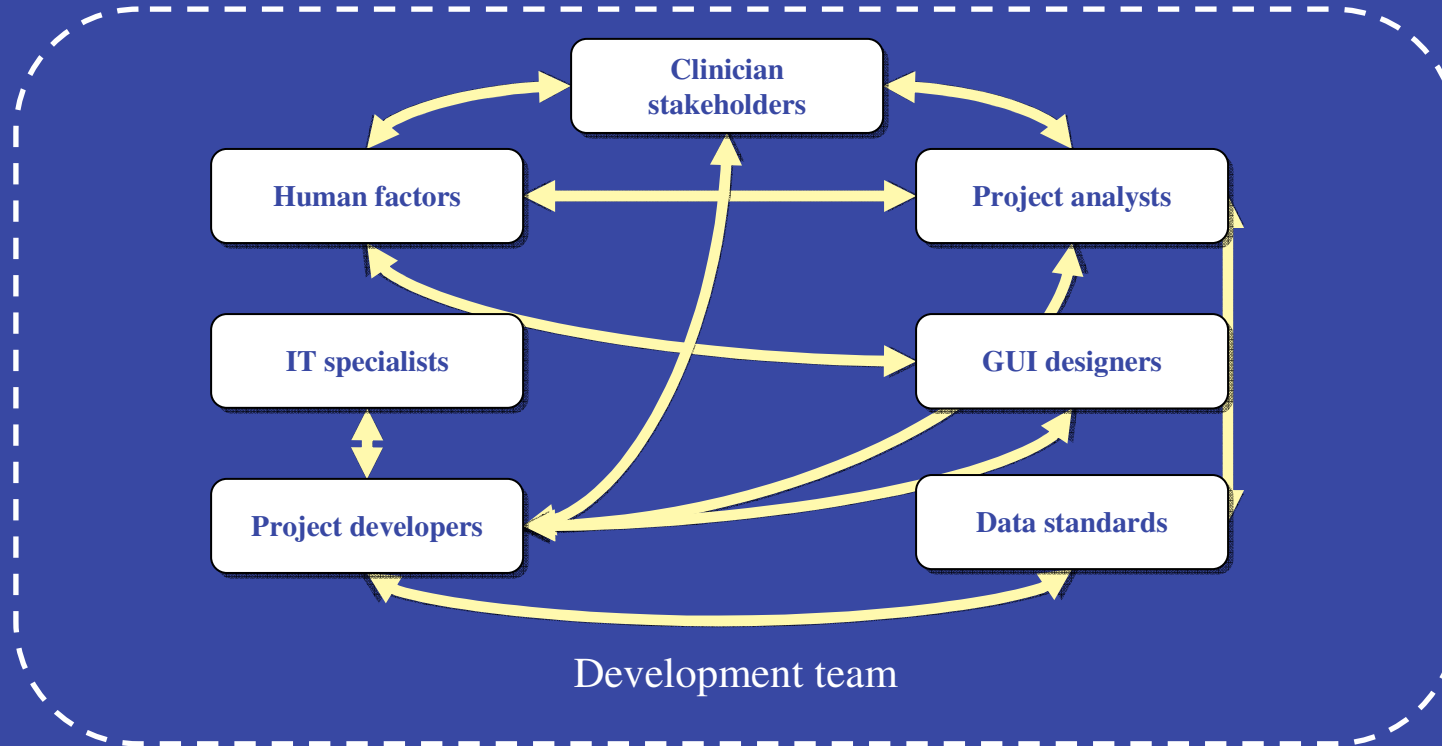
Implementation

- Silos of knowledge in electronic healthcare



Implementation: Team

- Multi-disciplinary development team
- Collaboration needs knowledge transfer



Implementation: Analysis

- Subset-driven design → Disease-specific requirements
- Search interface → Multiple services



Implementing Subsets

Executive summary Clinical history Operative note Final details Sign-off note

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Past Gynecologic Surgeries

- Subtotal hysterectomy
- Total hysterectomy
- Left oophorectomy
- Right oophorectomy



Implementing Subsets: Design

- Challenge #1: Design and collection of specifications:
 - How to model the data to capture all clinical scenarios?
 - What data points and form fields?
 - What checkbox and dropdown options?
 - Can a data point be encoded using SNOMED CT data?
 - Can the desired options be mapped to SNOMED CT codes?
- Clinician-driven specifications only capture most common scenarios



Implementing Subsets: Design

- What they want

Location:	Had tumour:	Tumour size (cm):
Left ovary	<input checked="" type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Right ovary	<input type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Left fallopian tube	<input checked="" type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Right fallopian tube	<input type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Left uterine adnexa	<input type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Right uterine adnexa	<input type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Uterus	<input checked="" type="radio"/> Yes <input type="radio"/> No	<input type="text"/>
Cervix	<input checked="" type="radio"/> Yes <input type="radio"/> No	<input type="text"/>



Implementing Subsets: Design

- What they want vs. What they need

Findings

(Search for finding to add)

1 **Finding:** Tumour

Tumour size (cm):

***Location:**

Left ovary|

Show sites for: **Pelvis**

[\(Check all\)](#)

<input checked="" type="checkbox"/> Left ovary	<input type="checkbox"/> Right ovary
<input type="checkbox"/> Left fallopian tube	<input type="checkbox"/> Right fallopian tube
<input type="checkbox"/> Left uterine adnexa	<input type="checkbox"/> Right uterine adnexa
<input type="checkbox"/> Uterus	<input type="checkbox"/> Cervix
<input type="checkbox"/> Cul de sac peritoneum	<input type="checkbox"/> Bladder peritoneum
<input type="checkbox"/> Left pelvic sidewall peritoneum	<input type="checkbox"/> Right pelvic sidewall peritoneum

Location:

Left ovary	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Right ovary	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Left fallopian tube	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Right fallopian tube	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Left uterine adnexa	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Right uterine adnexa	<input type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Uterus	<input checked="" type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>
Cervix	<input checked="" type="radio"/>	Yes	<input type="radio"/>	No	<input type="text"/>



Implementing Subsets: Design

- Results:
 - Several iterations of the design were needed
 - Ovarian cancer: 38 subsets, 276 SNOMED CT terms
 - Ambulatory: 138 subsets, 1254 SNOMED CT terms



Implementing Subsets: Mapping issues

- Time consuming:
 - 6 analysts, ~500 work hours to identify/refine/verify 1530 codes with clinicians
- Vocabulary specialist needed clinical knowledge to correct 99 mapping issues out of 1530 mapped terms:
 - “SLAP tear” = a tear to the labrum
 - “lesser sac” = omental bursa
 - “left adnexa” = left uterine adnexa or left ocular adnexa?
 - “gastronomy tube (a physical object)” instead of “insertion of gastronomy tube (procedure)”



Implementing Subsets: Missing terms

- Out of 1530 concepts:
 - 211 were not found:
 - Inadequately refined: “Left femur”
 - Qualifiers needed: “Laparoscopic splenectomy”
 - Too specific: “Surgical repair of facial fracture”
 - 100 lacked preferred synonym, e.g. “Ovarian cancer” instead of “Cancer of ovary”



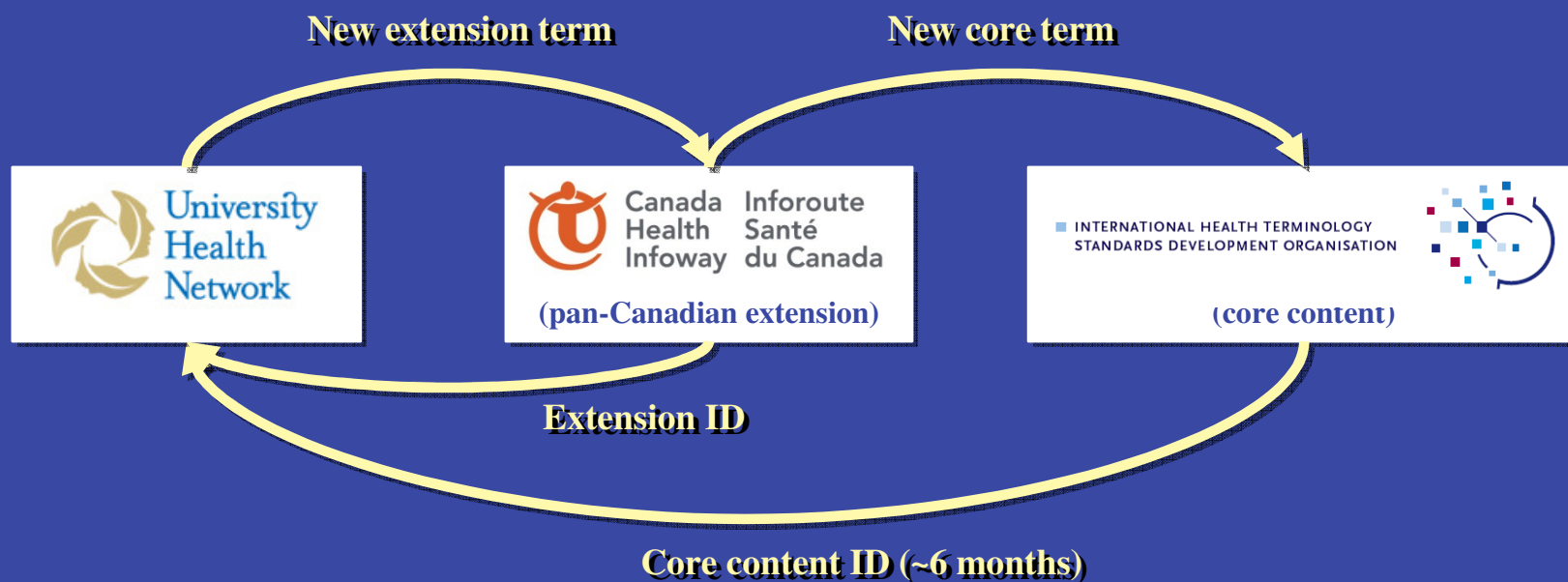
Implementing Subsets: Missing terms

- Post-coordinated terms:
 - Can't be included in subset or search indexing mechanisms
- Extensions:
 - Canada Health Infoway maintains pan-Canadian extension and governance of jurisdictional extensions



Implementing Subsets: Missing terms

- Content submission process:



Implementing Subsets: Missing terms

- Incompatible with project timelines:
 - 6 month delay, possible rejection
- Compromise: Local unofficial extension mechanism required
 - Can be searched along with core content
 - Can be mapped back to pan-Canadian extension and core content



Implementing Search



Implementing Search: Version #1

- When subsets are insufficient or encoding subset outliers
- Basic keyword search with standard interface:

The screenshot displays a web-based search interface. On the left, there is a form with two input fields: 'Most responsible diagnosis:' with a 'Select value...' button, and 'Other MRDX:' with an empty text box. On the right, a modal window titled 'Find value for 'Most responsible diagnosis':' is open. It contains a 'Close' button in the top right. Below the title, it says 'Items recently selected by you:' followed by 'None.'. A section titled 'Start a new search:' contains a search input field with 'type 1 diabetes' and a 'Search' button. Below this, it says 'Select values from search results:' followed by a list of two items, each with a checkbox: 'Diabetes mellitus type 1' and 'Type 1 diabetes mellitus without complication'. A 'Close' button is located at the bottom of the modal window.



Implementing Search: Version #1

- Issues:
 1. Too many results

Find value for 'Most responsible diagnosis': Close

Items recently selected by you:

None.

Start a new search:

diabetes Search

Select values from search results:

- Diabetes mellitus syndrome in newborn infant
- Neonatal diabetes mellitus (disorder)
- Neonatal diabetes mellitus
- Diabetes mellitus associated with pancreatic disease
- Secondary pancreatic diabetes mellitus
- Diabetes mellitus associated with pancreatic disease (disorder)
- Diabetes with hyperosmolar coma (disorder)
- Protein-deficient diabetes mellitus
- Malnutrition-related diabetes mellitus - protein-deficient
- Protein-deficient diabetes mellitus (disorder)
- Central diabetes insipidus
- Diabetes insipidus secondary to vasopressin deficiency
- Pituitary diabetes insipidus
- Cranial diabetes insipidus
- Primary central diabetes insipidus

Close

Implementing Search: Version #1

- Issues:
 1. Too many results
 2. Silly results

Enter text for search:
warfar Search

Select values from search results:

- Warfarin toxicity
- Poisoning by warfarin sodium
- Poisoning by warfarin sodium (disord
- Warfarin poisoning
- Victim of civil warfare (finding)
- Victim of civil warfare
- Victim of naval warfare (finding)
- Victim of naval warfare
- Victim of international warfare
- Dysmorphism due to warfarin
- Fetal warfarin syndrome

Accept



Implementing Search: Version #1

- Issues:
 1. Too many results
 2. Silly results
 3. Missing results:
 - Qualifiers: “Severe asthma”, “Suspicion of cancer”
 - Refinement: “Excision of left kidney”
 - Short forms: “DM”, “STEMI”, “Vulvar cancer”



Implementing Search: Version #1

- Issues:
 1. Too many results
 2. Silly results
 3. Missing results:
 - Qualifiers: “Severe asthma”, “Suspicion of cancer”
 - Refinement: “Excision of left kidney”
 - Short forms: “DM”, “STEMI”, “Vulvar cancer”
 4. Slow
 - User frustration → Abandonment of search



Implementing Search: Version #2

- Auto-complete text field
 - Improved interface
 - Improved search algorithms

Add medical condition:

diabetes mellitus type 2

- Diabetes mellitus type 2
- Diabetes mellitus
- Diabetes mellitus type 1
- Brittle diabetes mellitus
- Neonatal diabetes mellitus
- Postpancreatectomy diabetes mellitus
- Protein-deficient diabetes mellitus
- Secondary diabetes mellitus
- Unstable diabetes mellitus
- Gestational diabetes mellitus, class A>2<
- Unstable type 1 diabetes mellitus

Only best matches shown, continue typing for more options



Implementing Search: Version #2

- Human factors exposed design assumptions

Scenario 1:

Add diagnosis:	
ovarian cyst	Add diagnosis
Ovarian cyst	
Complicated ovarian cyst	
Developmental ovarian cyst	
Functional ovarian cyst	
Haemorrhagic ovarian cyst	
Only best matches shown, continue typing for more options	

Scenario 2:

Add diagnosis:	
advanced lung cancer	Add diagnosis
CA - Lung cancer	
Non-small cell lung cancer	
Small cell lung cancer	
Secondary cancer of lung	
Candidiasis of lung	
Neonatal candidiasis of lung	
Start typing to search for more options	



Implementing Search: Version #2

- Human factors exposed design assumptions
- Psychological considerations for:
 - Different user demographic
 - Different purpose for searching



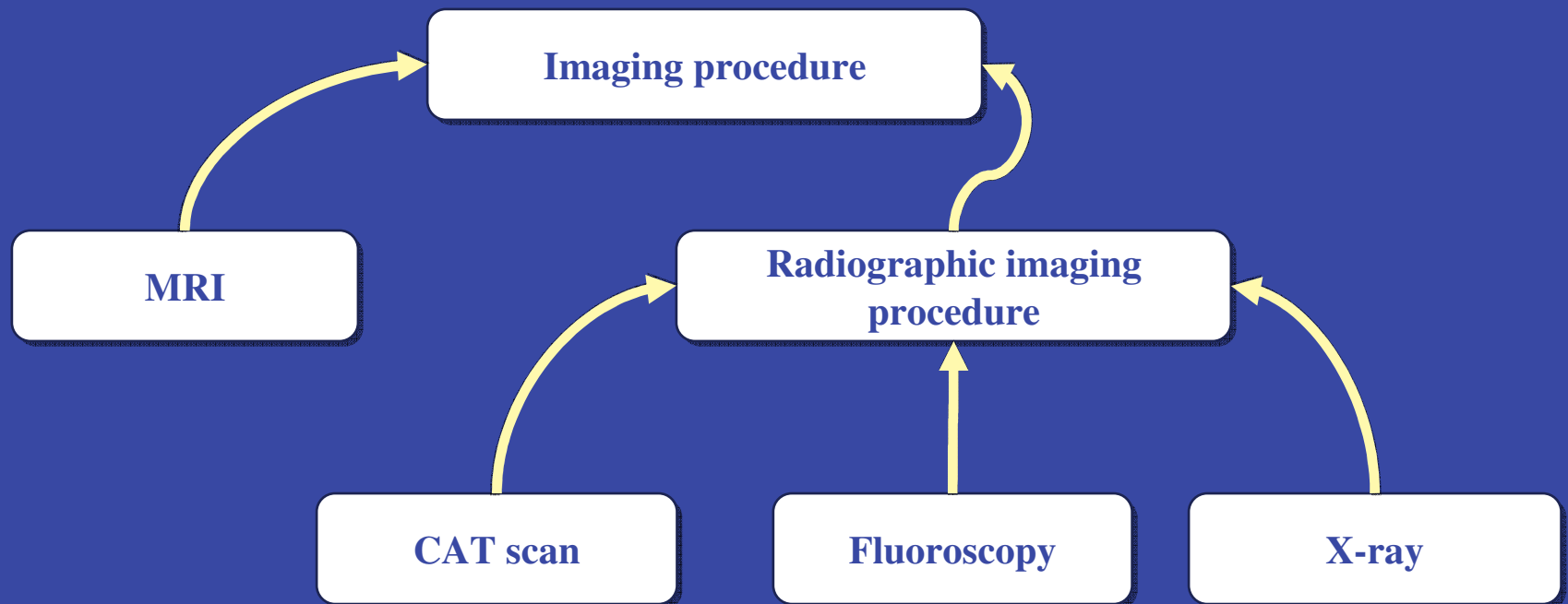
Implementing Search: Algorithms

- Prioritize more frequently used terms relevant to a specialty or disease
- Hide redundant synonyms
- Limit to terms that fall under a certain classification, e.g. surgical procedures, disorders, etc.
- Had to be fast and efficient:
 - With limited budget and resources
 - Without server cloud
 - Without team of computer science PhD's



Implementing Search: Algorithms

- Use SNOMED CT relationships to search only imaging procedures?



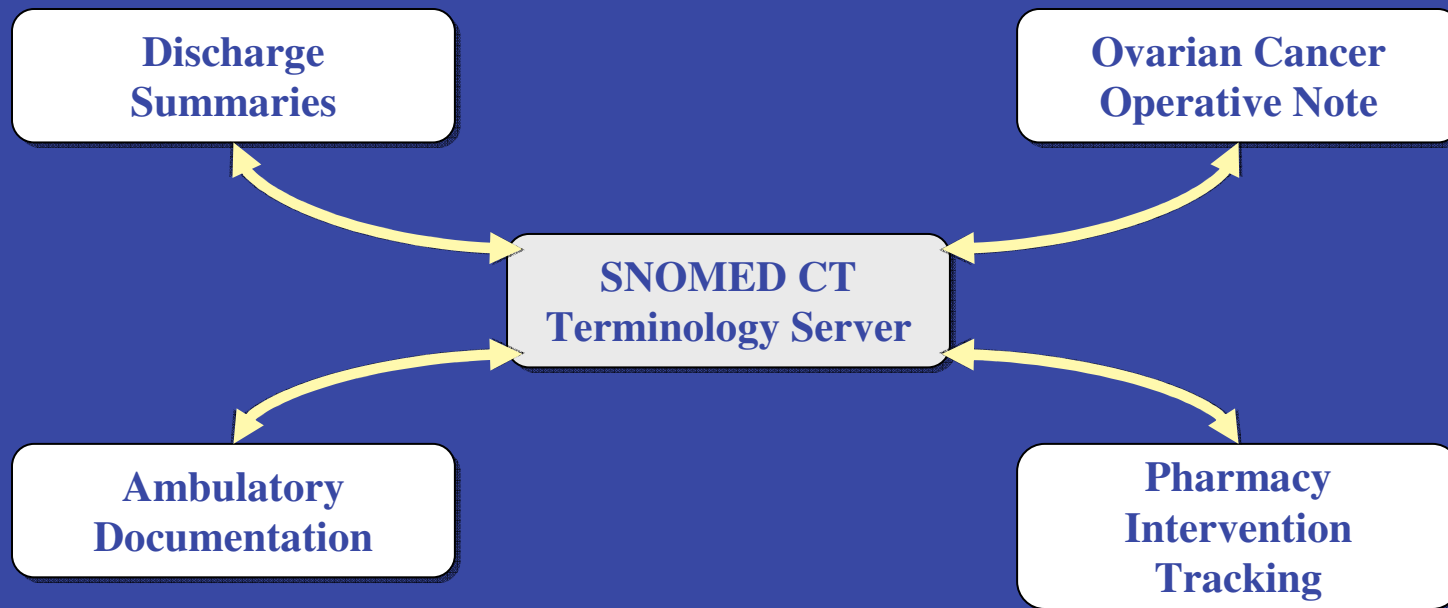
Implementing Search: The Technical Stuff

- Traversing directed acyclical graphs
- Transitive closure:
 - Generating inferred relationships took **2 days on my laptop**
- Customized indexing technique for relational databases



Implementing Search: Cool Stuff

- Terminology server:





Implementing Search: Cool Stuff


- Intelligent form templates:

Findings

(Search for finding to add) Had finding: Yes

1  *Weight loss: Yes No
Amount: lbs

2  *Losing weight: Yes No
Amount: lbs

3  *Intentional weight loss: Yes No
Amount: lbs



Implementing Search: Cool Stuff

Head and neck exam: Performed Not performed

Findings

(Search for finding to add) Had finding: Yes

1 *Bone tenderness: Yes No

Location:

Type, or select from list below:

- | | |
|--|---|
| <input type="checkbox"/> Frontal bone | <input type="checkbox"/> Nasal bone |
| <input type="checkbox"/> Maxilla | <input type="checkbox"/> Left zygoma |
| <input type="checkbox"/> Left zygomatic arch structure | <input type="checkbox"/> Right zygomatic arch structure |

2 *Abnormal vascular flow: Yes No

Location:

Type, or select from list below:

- | | |
|---|--|
| <input type="checkbox"/> Left common iliac artery | <input type="checkbox"/> Right common iliac artery |
| <input type="checkbox"/> Right common carotid artery | <input type="checkbox"/> Left external iliac artery |
| <input type="checkbox"/> Left external carotid artery | <input type="checkbox"/> Right external carotid artery |
| <input type="checkbox"/> Left ulnar artery | <input type="checkbox"/> Right ulnar artery |



Concluding Thoughts

- Secondary clinical benefits of data standards
- New ways to meet clinical needs
- Clinical knowledge of clinician workflow, culture, practice and needs
- Technical knowledge of advanced computer science techniques
- Invisible SNOMED CT
- Knowledge transfer, multi-disciplinary collaboration is essential



Questions

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