WEB 3.0 AND HEALTHCARE: SEMANTIC INTEROPERABILITY AND STABILITY FOR MEDICAL APPLICATIONS

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WHY EVERYTHING ELSE IS COMPUTERIZED, BUT HEALTHCARE?
Effective healthcare systems respond quickly to changes in demographic and epidemiological profiles of the population.

These changes are often unexpected. Examples:
- Zoom out: when there is an epidemic (or tsunami)
- Zoom in: anytime the emergence of a large hospital

In paper-based healthcare systems, it takes weeks to identify an epidemic (zoom out) or an outbreak of MARSA in a hospital (zoom in).

For decades, it has been promised that these problems will disappear with the computerization of healthcare services.

The fact is that such promises have not been fulfilled yet.

**Why?**
Why is it so easy to computerize everything (banks, tax and fine collection, e-commerce) and it is so difficult in healthcare?
**E-HEALTH JUST BECAUSE?**

- Flooding the healthcare system with hardware (and the corresponding embedded software) has an insignificant effect on the improvement of individual population and health outcomes.
- No illusions: NOTHING will NEVER surpass the effect of the improvement in income, sanitation and immunization coverage.
- However, it takes millions or even billions to computerize, without planning, healthcare systems.
- There is not much critical mass in the technical areas of government (or private hospitals) on software quality for healthcare.
- Medical software is purchased or developed with the same software architecture adopted for video rental stores, gas stations or bank tellers.

Trust me: It is not going to work.
But why?

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**ONE PARENTHESIS**

- Just for not to give the impression that the problem of medical informatics is merely the software quality:
- Imagine the medical software with the best quality possible, based on traditional modeling, installed in Clinical C.
- The patient goes to clinic C to make a preoperative catheterization, but the pacemaker surgery will be done at the Hospital H, which also has a similar software.
- It does not matter how good both software are, the context of information collected in Clinic C is "trapped" in the data model defined in the code of the Software C, and the same for Software H.

Back to the question: Why software modeling being used in all other economy sectors is not effective in healthcare?
WHY HEALTHCARE IS DIFFERENT?

- Healthcare is the only sector of the economy that deals with biological production processes (created by nature).
- All other sectors of the economy deal with industrial production processes (created by man).
- Man-made production processes created by man are simpler than biological because:
  - Evolution had millions of years to reach such complexity.
  - Human civilization starts just dozens of thousands of years ago.
  - Biological systems are as complex as necessary to guarantee the survival of the species.
  - Industrial systems are as simple as possible to maximize profit.

I had such ideas reading: Dawkins R. The greatest spectacle on Earth, pp. 204-5 (and Marx, of course).

DYNAMICS AND COMPLEXITY IN HEALTHCARE

- Healthcare systems are much more complex than anything else in the world regarding 3 dimensions:
  - Space
  - Time
  - Ontology
Two cities can be neighbors and have completely different healthcare needs (e.g., Córdova and Saldán).

Better said, two neighborhoods can be neighbors and have completely different healthcare needs!

Better said, two buildings in the same street can be neighbors and have completely different healthcare needs.

Better said, two people living together can have completely different healthcare needs.

Better said, your heart and your feet DO HAVE completely different healthcare needs.

Better said, two alleles that determine completely different diseases will have different genetic therapies in the future.

Zooming Out...
SPATIAL COMPLEXITY (2)

TEMPORAL COMPLEXITY
TEMPORAL COMPLEXITY
TEMPORAL COMPLEXITY

Zooming In...
TEMPORAL COMPLEXITY

Unfortunately, the cute pictures are over.
### ONTOLOGICAL COMPLEXITY

- The largest medical terminology (SNOMED-CT) has more than 310,000 terms connected by over 1,000,000 links
- This means that in medicine, there are about 310,000 concepts interconnected by millions of different forms
- In practical terms, this means that deploying a "megalithic system" that all healthcare services could use would require deploying a system with a huge amount of tables with 310,000 fields and millions of relationships among themselves

**Cavalini-Cook Conjecture:** The probability of consensus between 2 or more experts regarding what would be the "maximum data model" for any given healthcare concept tends to zero

### WHAT DOES THIS COMPLEXITY CAUSE?

- This complexity makes a computer science problem that does not exist (or it is not critical) in any other sector of human society to be very severe in healthcare.
- This problem is:**Semantic Interoperability**
SEMANTIC INTEROPERABILITY

For common mortals:
- Semantic interoperability is the ability to send an information extract from system A to system B, and from both to system C, and vice-versa, and so on, being all those information extracts semantically valid in all systems.

All systems read and understand all information extracts from all other systems.

Syntactic integrity is also important:
- Otherwise, the Semantic Web would have solved the problem of healthcare IT
- That is not the case, because the Semantic Web marks up data instances
- The syntax of each application is still incompatible to any other
A person can be a member of several video rental stores. Your rental history at the video store A in no way affects the customer service one will receive at the video store B.

In healthcare, everything is interconnected!

What happened when the patient was seen at the primary care setting is CRITICAL to define the treatment at the hospital.

“Oh, but the patient can tell.”

But many patients are unconscious or under the influence of psychotropic drugs in the most critical moments of their lives, and families around are crying and not well informative either.

That (and similar things that work for other industries) have been tried in healthcare since 1961, with a cost of billions of dollars and euros, and nothing has worked.

Semantic interoperability is critical, but the time complexity brings an unavoidable problem even for self-contained systems.

In healthcare, you define your data model today and it does not last six months, because the concepts are evolving quickly and new concepts appear every day.

The average time for a medical software to be abandoned is 2 years and the dropout rate is 70% (source: CHAOS Report).
Many (very expensive!) things were and still have been proposed to solve the problem of semantic interoperability and reduce the maintenance costs of applications in biomedicine, with no clear results.

Adding to that the fact that healthcare is the most conservative sector of society, the result is that healthcare is the only system that still relies entirely on paper.

Lobbyists knock at the governments’ doors all the time, claiming that they have at hand the solution to the problems of e-health, and governments, afflicted with political pressure and complaints about the quality of the healthcare system, buy that and waste hundreds of millions of [currency].

Software companies do not want to develop healthcare products because it is complicated and customers are never satisfied.

CONSEQUENCE

The two main Standard Development Organizations in health informatics are:

- Health Level 7 (HL7)
- International Standards Organization (ISO)
**HL7**

- *Health Level 7 Inc.* is the enterprise that develops the HL7 standard since 1987
- HL7 is a healthcare information exchange standard accredited by the *American National Standards Institute* (ANSI)
- There are two versions of HL7:
  - HL7v2
  - HL7v3

**HL7(V3): CHALLENGES**

- Despite the New Day... initiative, which presents several unresolved issues regarding intellectual property, the fact is that HL7 is still a commercial standard
- The standardization of messages restricts the modeling of clinical concepts - most messages are directed to the administrative part of the systems
- It has been created a Babel of initiatives around HL7 going in different directions - the solution has become part of the problem
- There is not a single proven record of implementing EHRs based on the HL7v3 RIM
- HL7 messages do not allow backward validation, because the RIM allows extensions
The slowness of the ISO process makes it irrelevant: more dynamic initiatives are adopted as *de facto* standards before becoming ISO (if that ever happens).

- The representativeness is based on the ability to participate in meetings, not on the actual market (producers or consumers) needs.

- Consequence: low level of implementation of the ISO Standards.

THE BASIC PROBLEM IS...
THE BASIC PROBLEM IS...
A HELIOCENTRIC SPIN

MULTILEVEL MODELING

A heliocentric standard for health informatics
MULTILEVEL MODELING PRINCIPLES

IN A SIMPLER WAY...

Your application (GUI, DSS, BI etc)

Domain Models

Reference Model
In multilevel modeling, the context of the information does not get “incarcerated” in the software. That is because the Reference Model is composed by generic classes which contain as minimal context as possible. The information context is contained, in an interchangeable format, in the Domain Models (archetypes or CCDs). Information collected at the point of care will have its context persisted forever: future changes in the software – keeping the Reference Model stable – will no longer affect the information content. These information extracts, containing the original context, properly space and time referenced, can be shared by any application based on the same Reference Model.

**BRINGING BACK THE CONTEXT**

**DOMAIN MODELING**

Archetypes (open EHR or ISO 13606) → CCD (MLHIM)

- Concept
- Constraint
- Definition
### HISTORY

<table>
<thead>
<tr>
<th>Last years of the 20th century:</th>
<th>US: Cook develops TORCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe: GEHR project turns into openEHR</td>
<td></td>
</tr>
<tr>
<td>Turn on the 21st century:</td>
<td></td>
</tr>
<tr>
<td>Cook tries to harmonize TORCH to openEHR</td>
<td>openEHR goes to ISO and negotiates the 13606 Standard family</td>
</tr>
<tr>
<td>2009:</td>
<td>MLHIM is launched</td>
</tr>
<tr>
<td>2013:</td>
<td>&quot;Spontaneous&quot; convergence of openEHR towards MLHIM</td>
</tr>
<tr>
<td></td>
<td>ISO 13606 future is uncertain</td>
</tr>
</tbody>
</table>

### THE KEPLERIAN PROBLEM OF MULTILEVEL MODELING

Kepler’s Problem
### A HELIOCENTRIC MODEL FOR A REAL WORLD

![Planetary System Diagram]

### MULTILEVEL MODELING APPROACHES

<table>
<thead>
<tr>
<th>Models</th>
<th>openEHR</th>
<th>MLHIM</th>
<th>13606</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>(Quasi) Maximalist</td>
<td>Minimalist</td>
<td>Reductionist</td>
</tr>
<tr>
<td>RM residual context</td>
<td>Intense</td>
<td>Minimal</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Data model</td>
<td>(Quasi) Maximum</td>
<td>Any size</td>
<td>(Uncertain)</td>
</tr>
<tr>
<td>Possible implementation</td>
<td>No data receiving mhealth</td>
<td>Any application</td>
<td>Only message exchange</td>
</tr>
</tbody>
</table>
### Knowledge Modeling Approaches

<table>
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<th>Models</th>
<th>openEHR</th>
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<th>13606</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Archetype</td>
<td>CCD</td>
<td>Archetype</td>
</tr>
<tr>
<td>Language</td>
<td>ADL</td>
<td>XML Schema</td>
<td>ADL</td>
</tr>
<tr>
<td># of structures / concept</td>
<td>(More than) one</td>
<td>Any number</td>
<td>(Uncertain)</td>
</tr>
<tr>
<td>Governance model</td>
<td>(Partially) top-down, consensus</td>
<td>Bottom-up, merit</td>
<td>(Uncertain)</td>
</tr>
</tbody>
</table>

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**BUT THE SUN IS NOT THE CENTER OF THE UNIVERSE...**
MEDWEB 3.0 is a social network for doctors and patients to share clinical, health and wellness information. Patients can create their own customized profiles and share with their doctors. The doctors can create customized profiles for their patients. Different personal and clinical profiles for clinics, hospitals and ambulances.
**MEDWEB 3.0 IS...**

- **Doctors can access the clinical profiles of their patients at any hospital**
- **They can share the clinical profiles to other doctors that take care of their patient**
- **They can access the clinical profiles other doctors created for their patients**
- **All those profiles are customized and shareable**

**MEDWEB 3.0 IS...**

- **Patients can share their customized profile to all their doctors**
- **They can check if the doctor already filled up their prescription**
- **They can share the blood pressure measured by their digital device**
- **They can share gym activity with their nutritionist and cardiologist**
### SOME MEDWEB 3.0 APPS

<table>
<thead>
<tr>
<th>Patient Profiler</th>
<th>Clinical Profiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>A MedWeb 3.0 app to create customized profiles for patients.</td>
<td>A MedWeb 3.0 app to create customized profiles for doctors.</td>
</tr>
</tbody>
</table>

### SOME MEDWEB 3.0 APPS

<table>
<thead>
<tr>
<th>Hospital Profiler</th>
<th>Nurse Profiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>An enterprise-level app to create clinical and patient profiles for hospitals.</td>
<td>Other healthcare professionals can create their own customized and shareable profiles for their patients.</td>
</tr>
</tbody>
</table>
SOME MEDWEB 3.0 APPS

**Clinical Alerts**
Clinical Profiler Plugins for epidemics report, ICU vital signs monitoring, lab reminders

**Patient Alerts**
Patient Profiler Plugins for medication, physical activity, BP measurement alerts

SOME MEDWEB 3.0 APPS

**MedWeb 3.0 Stats**
Personalized reports for doctors about their patient's data (% of diabetics, cure rates)

**Clinical Research Apps**
Clinical trial enrollment, genomics and proteomics data sharing, medical surveys
WHAT HAVE WE DONE SO FAR

- Multi-Level Healthcare Information Modeling (MLHIM)
- Clinical Component Generator (CCD generator)
- Health Knowledge Component Repository (HKCR)
- The complete informational infrastructure
- The Patient and Clinical Profiler Generator
- The Patient and Clinical Profile Repository

THANK YOU!

“YOU NEVER CHANGE THINGS BY FIGHTING THE EXISTING REALITY. TO CHANGE SOMETHING, BUILD A NEW MODEL THAT MAKES THE EXISTING MODEL OBSOLETE.”

- BUCKMINSTER FULLER

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SADID

MédiaWeb 3.0