Overarching HL7 Interpolation For Asian Interoperability

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***Abstract*-This paper takes a sneak-peek at the state healthcare sector in Sri Lanka. It looks at the number, type, and location in Sri Lanka, of the over 1600 state-run medical institutions, ranging from the small rural clinics, to the large city hospitals, the currently used healthcare-related IT technology in these institutions, the issues and shortcomings, the desired IT technology and service levels in healthcare, and the applicability of the Health Level 7(HL7) healthcare standard to elevate the IT services and its usage in healthcare in Sri Lanka, both vertically down the different healthcare-service-provider tiers, and laterally in terms of increasing demographic spread, related improvement in the relevant system performance indicators, and finally an *extrapolation* of these findings to the global context. The study employed valued, timely, and relevant data collected about the healthcare sector in Sri Lanka in the analysis and solution phases, but the findings are ubiquitous and overarching, seamlessly extrapolatable to the Asian and greater universal contexts as well.**

Index Terms: *Health Information System, HL7, Semantic Interoperability.*

I. INTRODUCTION

The mission of Sri Lanka's Ministry of Health's (MOH's) healthcare endeavour (including eHealth), as defined in **[2]** is "*to provide quality and timely health information for evidence-based decision making through the establishment of a ubiquitous, integrated, dynamic, resilient, cost-effective, and sustainable Health Information System* (HIS)".

Many state hospitals and medical facilities around the island have installed bespoke, turn-key healthcare-related IT solutions. These automated *Hospital Healthcare Information Management Systems* (HHIMS) which have supplanted their legacy, antiquated, manual counterparts, are networked, web-based solutions with native backend database management systems (DBMS). For instance, healthcare facilities in Tsunami affected areas (the Tsunami hit the Sri Lankan southern coastline in December 2004) received IT-related funding expeditiously from many foreign aid agencies. The participating *implementation* software vendors have been wide and varied depending upon the nature of the aid, its source, the price, after sales service, and individual preference of the aid giving organization and/or the recipient healthcare institution.

The standards if any with regard to the developed and implemented *HHIMSs* are inherent to the particular turnkey application or the *software-house* developed solution. The non-adherence to universal healthcare standards such as *Health Level 7*(HL7) lead to totally arbitrary, inconsistent, often incongruous and non-uniform solutions; a death knell for our sacrosanct mission of achieving comprehensive and efficient *semantic interoperability* in application. The use of *symbiotic* standards such as HL7 serve to formalize, regulate, and homogenize application specifications development. Health Level 7 **[1]** is a global, non-profit body which introduced the HL7 healthcare standard in 1987.

The prudent HL7 standard interpolation would promote the broadbased, cost-economic use of the universal healthcare standard in order to achieve *multi-phase* interoperability, efficacious and efficient data and information exchange amongst stakeholders, and a resulting *exponential* improvement is healthcare levels nationwide. Implementation-wise, a cloud-based, distributed solution would be optimal for our needs.

II. PRESSING REQUIREMENTS OF IT-ORIENTED HEALTHCARE AT PRESENT

The main goals as enunciated by the Ministry of Health in regard to any new healthcare-related, standard-driven IT system are as follows

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[2][3] :

- Semantic Interoperability
- Security – Data, hardware, Software, Infrastructure
- Sustainability of system
- Provision of useful data and timely information to Management
- Uniformity in design, development, and implementation
- Confidentiality – of sensitive patient data (conform to medical ethics)
- Broadbase the standard's use in Sri Lanka

In addition, the MOH teams also formulated a set of *overarching* guidance principles surrounding the implementation of the national health information policy. This set of guidance principles is listed below [2][3]:

- Citizen centric approach
- Good governance and transparency
- Upholding national values of free healthcare, right to health, universal coverage, equity and social justice.
- Ensuring quality and safety in care delivery.
- Encouraging multiple stakeholder involvement , collaboration and partnerships for information dissemination and sharing.
- Evidence based decision making and accountability.
- Ensuring privacy and confidentiality of healthcare recipients.
- Sensitivity towards cultural diversity and social norms.
- Systems approach to health information with a focus on interoperability.
- Minimal data redundancy in data capture.
- Conformity to technology relevance , simplicity, cost effectiveness, and judicious and efficient use of information resources.
- Sustainability of the information system.

In fact, it is shown in the next section that the proposed new HL7-based solution does in fact adhere to them all; it fulfills the MOH goals as listed, and satisfies the said guidance principles of eHealth policy implementation.

III. PROPOSED NATIONWIDE HL7-BASED IT SOLUTION AND ALLIED HEALTHCARE ENHANCEMENT

"*The government of Sri Lanka is committed to provide universal access to essential healthcare that would benefit its people through preventive and curative healthcare services*" [2]. The key phrase in the preceding paragraph is the *provision of universal access to healthcare services*, meaning, an essential universal (national/international) *nuance* to semantic interoperability. This is where the HL7 standard *interjects*. Blended with the *Services Aware Interoperability Framework* (SAIF) technology[4] which injects *semantic interoperability* amongst participating HL7 enterprises(blended standard known as HL7-SAIF), our new proposed solution would cover the *entire stretch* of the preset goals and objectives of MOH's mission to nurture and enrich the *germination* and *proliferation* of an organized, regulated, standardized, nationwide, interoperable healthcare IT network. Thus, using the HL7-SAIF standard for regularized IT specifications development, we can extend the lateral demographic spread of nationwide IT use in healthcare stretching to *far-flung* regions and interior *nooks* hitherto uncovered. In fact, this paper proposes a "*universal-interoperability-ready IT-driven national healthcare system specification template*" from which the derivation of situation or healthcare-facility-specific *bespoke* specifications would be a mere formality.

This research has taken *great pains* in enhancing the current HL7 standard; it is *SAIFly* blended to yield the *near-exponential* enhancement and return in the level of nation-wide healthcare. The development and use of the *Grand National specification template* for the IT-based, nationwide healthcare solution would enable and facilitate the *effortless*, *painless*, and *seamless* development of budgets and cost-benefit analyses. Once set up, the HL7-SAIF standard (as used this study) and the grand specification template would consummately fulfill every goal in MOH's mission to nurture and maintain an interoperable, nationwide, healthcare IT solution, vastly improving and enhancing the patient care in the island. In addition, the solution would also be *antennae-ready* for connectivity to Asian and even international HL7-based interoperability healthcare networks *on demand*, with minimal extensions.

IV. RESULTS

The following table lists the MOH's aforementioned goals, guidance principles of policy implementation, and the most pertinent policy statements, all related to eHealth, in short referred to as the *eHealth mission*, and how the new proposed HL7-based solution fulfills them.

TABLE 1
PROPOSED HL7-BASED SOLUTION – MOH'S MISSION ACCOMPLISHED

No	Description-MOH eHealth Goal	Research Solution
1	Semantic Interoperability	Achieved through the use of HL7-SAIF.
2	Security-Data, Hardware, Software, Infrastructure	Achieved through archaic security methods – secured logins, virus guards, firewalls, etc.
3	Sustainability of system	Proper, regular budgetary allocation, Excellent Training programs, Well-Trained Staff.
4	Provision of useful-timely data/ information to management	New solution with enhanced HL7-SAIF standard will ensure this.
5	Uniformity in Design, Development, and Implementation	New solution with enhanced HL7-SAIF standard will ensure this..
6	Confidentiality – of sensitive Patient Data, ie, ensuring privacy and confidentiality of healthcare recipients.	Stringent procedures for data access, transmit and use should be in place. Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this.
7	Broadbase the HL7-SAIF standard's use in Sri Lanka.	Greater knowledge about the benefits and use of the HL7-SAIF standard will ensure this..
	Description-MOH Guidance Principle, eHealth Policy Implementation	Research Solution
8	Citizen Centric Approach	Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this.
9	Good governance and transparency	The new HL7-based solution ensures consummate transparency through its interoperability in semantics and exchange. This in turn promotes good governance.
10	Upholding national values of free healthcare, right to health, universal coverage, equity and social justice.	Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this.
11	Ensuring quality and safety in care delivery	Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this.
12	Encouraging multiple stakeholder involvement, collaboration and partnerships for information dissemination and sharing.	The new HL7-based solution ensures consummate transparency through its interoperability in semantics and exchange. This promotes multiple stakeholder involvement, collaboration and partnerships for information dissemination and sharing.
13	Evidence based decision making and accountability.	The new HL7-based solution ensures consummate transparency through its interoperability in semantics and exchange. This promotes Evidence based decision making and accountability.
14	Sensitivity towards cultural diversity and social norms.	Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this. Due regard has to be given to the said *stratifications* and should be infused into the *national template of specifications* as tiers/clusters.
15	Systems approach to health information with a focus on interoperability.	Good eHealth Policy Formulation and Implementation, together with the new HL7-based solution in operation, both working in tandem would ensure this. Good interoperable specifications promote good quality, resilient system development.
16	Minimal data redundancy in data capture	Stringent specification developed using the HL7 standard would ensure this.
17	Conformity to technology relevance, simplicity, cost effectiveness, and judicious and efficient use of information resources.	Using the new HL7-based solution promotes and ensures that these attributes are fulfilled.
18	Continuous healthcare of patients ensured by *perennial* health record	The new HL7 -based solution together with the enhanced HL7-SAIF standard ensures this by the use of PIDs (Patient IDs)and HINs (Health Information Numbers).

Points 2 and 3 above relate to general IT procedures of any secured IT-driven system. Hence the HL7-SAIF standard does not directly deal with them.

As tabulated above, the new proposed HL7-SAIF-based solution incorporating the enhanced, improved *HL7-SAIF standard* and the *Grand National Specification Template* would comprehensively and consummately fulfill MOH's mission as defined in **[2]**. Quantifying the above tabular analyses, it can be seen that 2 of the *Type* statements relate to archaic IT system procedures, whilst the balance 16 *Type* statements (of a total of

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18) directly relate to the proposed HL7-based solution,

$\Rightarrow$ (16/18) x 100

$\Rightarrow$ ***88.89%*** of the MOH's *concerns* with respect to its *eHealth mission* and its implementation are efficaciously, efficiently, and consummately fulfilled by the proposed HL7-based solution.

This (***88.89%***) is indeed a significantly high "*always go*" percentage and a convincing reason for adopting the HL7-SAIF standard nationwide; it is indeed *ubiquitous, integrated, dynamic, resilient,* and *cost-effective*, and would unequivocally interpolate islandwide interoperability.

V. PROPOSED IMPLEMENTATION OF IT-BASED HEALTHCARE TECHNOLOGY NATIONWIDE

We propose the concept of *Computerettes* (similar jargon to *Launderettes*). In our *computerette* model, small, independent, self-contained, computing units are assembled for entire healthcare facilities, one unit per facility. They consist 1, 2, or 3 computers based upon the size, type of the facility, which are interoperability-ready and linked to the *logical cloud server*. They are equipped with a central *Uninterrupted Power Supply (UPS)* unit, central air-conditioning, central printer, and adequate lounging area for medical staff to peruse any documentation. This arrangement is far more economical than a system of kiosks with the same conveniences, as essential peripherals such as UPSs and printers need to be purchased in multiple units for the kiosk arrangement; single units of these peripherals per *computerette* per facility is a far more economical setup . Even the cabling required is simpler and cheaper in the centralized computerette arrangement; *pulling cables* to interconnect spreadout kiosks with the *console* computer would be expensive and intricate. *Wireless Access Points* (WAPs) are located in an *strictly-economized* arrangement at critical locations around the facility, and these provide wireless access to the *computerette cloud* server.

The computerette model is recommended situations such as the following :

1. A small, confined arrangement is preferred due to budgetary, space-related, personnel, or other constraints.
2. An economical, optimized solution is desired. By far the computerette model is the most economical option; the full-blown hardware solution on the other hand with a *desktop-per-table* arrangement is the most expensive with the least ROI. The reason for this is that most of the superfluous hardware become redundant and under-utilised and a waste of the initial heavy investment. Alternatively, the kiosk solution gets to be very expensive if the kiosks are widely spread (because of the extra cabling required) and multiple numbers of peripherals (egs., printers, UPSs) are purchased to cater to the multiple kiosks, giving the same throughput of a *computerette*. Much of this hardware and peripherals would also be under-utilised.
3. To get *maximum yardage* from a fixed budget allocation.
   This indeed is an "*eat the cake and have it*" solution; the computerette model being a super-economy solution would budget-wise enable multiple implementations spread islandwide. This would facilitate the broadbased, islandwide implementation of the IT-based, healthcare-related, interoperability solution using the *HL7-SAIF* standard. The *computerette* model would enable the uniform *ramping-up* from the handful of currently disconnected *HHIMSs pockets*, to an *overarchingly-interoperable* nationwide healthcare solution facilitated by the *HL7 standards* solution; and all this at a miserly cost.

The current *estimated* market prices of the following *computerette-related* equipment/services in Sri Lankan Rupees (SLR) are as follows.

Cloud Service	*Unchanged Fixed Cost*
Computer System (C)	50,000/=
Printer (P)	15,000/=
Central UPS (U)	25,000/=
Wireless Access Point (WAP)	10,000/=
Air-Conditioning (AC)	*Part of Facility utilities, not an incremental cost*

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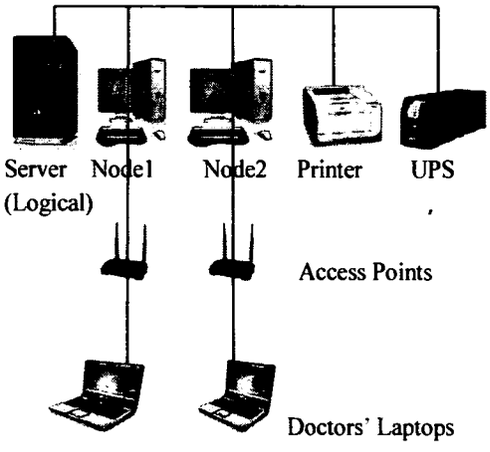
External storage devices (ES) *Ancillary cost*

ADSL connection (SLT) – high speed line
Unchanged (minimal) Fixed Cost

Fig. 1. A Model Computerette with Two Client Nodes



Cost of overall cabling (CB) *Optimal solution - with minimal cabling cost*

Cost to use HL7 Standard *Currently licensed at No Cost*

Note : Assume a suitably confined, secured space is available for the *computerette* in the respective facility.

The available hierarchy of healthcare facilities available in any *Province* (and thereby under its direct *jurisdiction*), or the *Line Ministry* (meaning under direct MOH purview) are tabulated below. These are facilities related to *human patient care* as opposed to public health veterinary facilities. Some provinces have multiple numbers of these individual facilities, but given below is the *barebones*, unique listing. The healthcare facility type and its advocated computerette *topology* are listed below. We propose a *maximal* 2 computers and 3 WAP per computerette per facility arrangement.

TABLE 2
NATIONWIDE HEALTHCARE FACILITIES AND RELATED COMPUTERETTE COSTS

Facility No.	Healthcare Facility	Advocated *Computerette* Hardware Topology & Estimated *Computerette* Cost (LKR)
1	Provincial General Hospital (PGH) (Care Facility)	2*C + P + U + 3*WAP = 170,000
2	Teaching Hospital (TH) (Care Facility)	2*C + P + U + 3*WAP = 170,000
3	District Chest Clinic (Care Facility)	2*C + P + U = 140,000
4	MOH Office (Administrative)	2*C + P + U = 140,000
5	Regional Malaria Office (Administrative)	2*C + P + U = 140,000
6	Regional Medical Supplies Division (Administrative)	2*C + P + U = 140,000
7	Provincial Director of Health Science (Administrative)	2*C + P + U = 140,000
8	STD Clinic (Care Facility)	2*C + P + U = 140,000
9	Base Hospital Type A (Care Facility)	2*C + P + U + 3*WAP = 170,000
10	Base Hospital Type B (Care Facility)	2*C + P + U + 3*WAP = 170,000
11	District General Hospital (Care Facility)	2*C + P + U + 3*WAP = 170,000
12	Divisional Hospital A (Care Facility)	2*C + P + U + 3*WAP = 170,000
13	Divisional Hospital B (Care Facility)	2*C + P + U + 3*WAP = 170,000
14	Divisional Hospital C (Care Facility)	2*C + P + U + 3*WAP = 170,000
15	Primary Medical Care Unit (Care Facility)	2*C + P + U = 140,000
16	Regional Director of Health Science (Care Facility)	2*C + P + U = 140,000
17	Special (Other) Hospital (Care Facility)	2*C + P + U + 3*WAP

In terms of healthcare facility *ownership*, we can visualize the *nine provinces*, the *Board*, and the *Line Ministry* as the legitimate owners of the 1600-odd medical facilities around the island.

VI. DISCUSSION

To "*tee off*" a systematic, nationwide implementation of the eHealth endeavour in pursuance of *overarching-interoperability* amongst stakeholder facilities with the help of the HL7-SAIF solution, we need perform a phase-wise implementation of the hardware. Hence, the following approach is implemented.

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All *owner-clusters*, ie., *Board Management, all nine Provinces*, and the *Line Ministry* pick the ten most *deserving* facilities in their respective clusters, to be *interoperable participants*. The criteria for selection of these ten participants are :

- *patient count in the case of a care facility.*
- *volume of patient EHRs processed at an administration facility.*
- significance in the data/information generated/processed /exchanged at the facility.
- seriousness of the diseases about which information is exchanged at the facility.

We use the maximal computerette cost which is SLR 170,000 in all our computations. The actual aggregated cost may be lower, never higher. All eleven owner-clusters will pick their *interoperable-partner-participants* as follows:

1. The Board Management will pick its two hospitals for *Interoperability*
   Hardware Implementation Cost = 170,000 x 2 = SLR 340,000
2. The Nine Provinces will pick their ten most significant participants respectively
   Hardware Implementation Cost = 170,000 x 10 x 9 = SLR 15,300,000
   (This costing assumes that all picked participants required high-end *computerettes* installed-meaning the more expensive *computerettes*)
3. The Line Ministry will also pick its ten most significant participants for *interoperability*.
   Hardware Implementation Cost = 170,000 x 10 = SLR **1,700,000**

Total Maximum Hardware Cost of Islandwide Implementation (Participating 102 Facilities Only) = **340,000 + 15,300,000+ 1,700,000**
= **SLR 17,340,000**

Thus, approximately SLR 17.34 million is the *maximum* cost of hardware of phase1 in the *most economical Computerette* solution, for islandwide implementation (for 102 participating facilities, cost-economy-wise a significantly high number). The total number of facilities available islandwide (as at May 30th, 2013) was 1679.

The following are important considerations in this phase-wise, islandwide implementation:

- The phase 1 of the islandwide implementation, albeit covering a small fraction of the total number of healthcare facilities available islandwide, ensures to cover the most significant *sub-clusters* of the facilities, thorough the selective picking process.
- Ensures that the uniform, islandwide activation and operation of *overarching-interoperability* amongst all participating facilities; a seamless solution inplace derived and developed by specifications generated by the HL7-SAIF Interoperability standard.
- The new proposed HL7-SAIF Interoperability solution ensures superior specifications generation, translating to a higher quality, precision, resulting system.
- Patients can be made aware of *participating* facilities in their respective provinces; those requiring their EHRs created and maintained would always travel to the closest *participating* facility.
- Scaling up to *infuse* more *participants* into the islandwide healthcare interoperability framework is relatively easy on new investment injection; systematically traverse facilities *cluster-by-cluster* and equip them with the appropriate *computerette*. The overarching healthcare-related IT solution will run in the *cloud*, with the *computerette* nodes being clients.
- Doctors and other medical personnel in the eHealth effort are encouraged to use personal laptops and gain access via the *WAPs* located facility-wide. This will prevent *crowding* in the *computerettes*; currently laptops can be purchased very cheaply and their liberal use in *participating* healthcare facilities would give an added impetus to our eHealth effort, whilst minimizing new hardware need and associated cost.
- The healthcare interoperability framework can be made *Internationally Interoperable*

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from day 1. Stringent adherence to the HL7-SAIF approach would ensure this.

- As enunciated in **[2]**, the implementation of a versatile *Healthcare Information System* (HIS) which generates quality, precision, and timely healthcare information will "*increase efficiency, improve cost-effectiveness, increase service delivery, afford universal access, reduce burden, improve health system performance and quality of healthcare*"; all converging towards our inceptive goal of *Asian and Universal Interoperability*.

VII. CONCLUSION

The procedures and specifications-oriented *HL7-SAIF methodology* was shown to improve and enhance the specifications generation process, providing overarching interoperability, and leading to higher-quality, precision, healthcare-related IT applications. This is true irrespective of the demographic location of the initial domain analysis, the intermediate location of the design and specification generation, or the destination of the final application implementation. The afore-mentioned three underlying phases can happen in three different continents, but the resulting system would be seamless if the *HL7-SAIF methodology* is strictly adhered to.

We also proposed a hardware solution applicable to all environments, ie., affluent, developing, and backward. The *Computerette* model was shown to be ideal for Sri Lanka, and for other countries in the Asian region. It is indeed the optimal, minimal cost hardware solution for healthcare facilities. Countries and their Health Services working with limited budgets would find this solution invaluable; it affords a *golden* opportunity to achieve national IT-related healthcare interoperability at a fraction of the envisaged cost. The fully-fledged IT option is far too costly for implementation at a national level for most economies, and the *kiosk* option is *deceptively* inexpensive, meaning, it *racks up the Rupees* with each add-on facility such as hardware peripherals; they end up being replicated an investment tab which most healthcare systems cannot bear. The *Computerette* model also provides easy, uniform scalability; new units can be added to the hitherto untouched healthcare facilities with minimal fuss, improving the total overarching interoperability. Hence it is an excellent option for more backward regions of the world such as Africa; poorer economies cannot afford the *fully-fledged* or *kiosk* options. Indeed then the proposed *Computerette* option becomes Hobson's choice, but is really the optimal solution in all respects.

Thus our proposed unified, coherent solution consisting of *HL7-SAIF methodology, the grand national specification template*, and the *facility-oriented Computerette*, form the backbone of any future interoperability-related national healthcare solution, vastly improving and enhancing the level of patient care in the island. The grand specification template can be *extrapolated* or *intrapolated* as required to mould the required bespoke solution. The devised solution would also be *antennae-ready* for connectivity to asian and even international HL7-based interoperability healthcare networks *on demand*, with minimal extensions.

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