Unified Application of Tele-healthcare Architecture and Globalized Patient IDs

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***Abstract*—Prevailing healthcare facilities comprising MMU (Mobile Medical Units), emergency helplines (e.g. 911) and tele-consultancy have been inefficient to save previous human lives. This is due to an unannounced and random movement (sometimes secret missions) at a distance of continents/countries by government officials, ambassadors, businessmen and tourists. The concept of paying much for security, health monitoring and getting highly insured against death now, do not allure human to make their life an money stack. The onsite healthcare availability of deceased has remained a big challenge and many governments had been looking after their patients within certain states of Europe or Canada with smart health card technology. This system becomes worthless when the deceased is found in critical health in those continents/ countries where such facilitation is not available, almost two-third part of the world. In our previous work [1] we proposed a solution to overcome these challenges of existing tele-healthcare during dire emergency situations. In this paper, we present schematic of a module capable to address the needs of Unified Tele-healthcare Network (UniTnet). The proposed module with the UniTnet 's theme serves a way to manage the interconnected healthcare resources in the vicinity of the deceased, auto-generates related signals and useful information about patient's history and present health conditions. Our contribution to medical and health sciences is to acquire smart procedures and efficient resource management to build a globalized real-time patient-specialist system.**

Keywords-component; Healthcare network, patient history, patient identity module, efficient healthcare system, decentralized tele-healthcare

I. MOTIVATION

Healthcare statistics from facilitation centers and medical insurance companies indicates that health and safety measurements are now in priority lists of most of organizations. However, during emergency situations, in congested metropolitan or remote locations (faraway from modern hospital) modern Tele-healthcare Facilitation Centers (TFCs) are of immense importance. The TFCs are designed to provide instant help to patients, better nursing, consultation with specialists via video conferencing, electronic appointments, medical history, appropriate treatment and immediate vital signs transfer along , if possible, the radiological the pathological reports (or at least their details) to remote specialist [1][2][3].

Major challenge for TFCs during emergency is the lack of onsite resources which may cause a slow start to medicinal services and therefore, threatens patient's life [4][5]. This lack is due to limited scope of healthcare services by traditional or proprietary TFCs. Today, TFCs are partially efficient within a private area networks like pre-designated areas or hospital. These TFCs do not offer global coverage or unified access to an endangered entity during emergency. In addition to this, TFCs infrastructure can't approach the patient's medical record, if he's not a resident of the coverage area. The access to medical record is again a delaying process. The problem turns the worst when patient is a tourist to the place and his medical profile is completely unknown. As a tourist he is not aware of nearby TFCs, specialists, dispensaries, hospitals, drug stores; so on and so forth. In existing infrastructure, TFCs do not offer quick access to medical record of a patient from other counties, countries or continents. Medical record of the patient is a valuable and essential asset, and is often bound to the survival and successful first aid to the patient [6][7]. At this stage, delays due to analysis and test of vital signs, for knowing all complex issues in the patient, may risk the life. Existing TFCs are failed to respond the expectations of roaming patients during critical/ non-critical situations [8][9].

After a profound analysis of existing TFCs and the role of communication networks we make some key observations. Based on observations, we necessitate a review of existing infrastructure of TFCs, which should be highly scalable, quickly and easily deployable with global acceptance. To address the patient's issues this prospective or revised infrastructure should be autonomous to share emergency information in case of emergency (even patient is unaware or

unconscious), to report basic (vital) signs and to make use of available telecommunication technologies in the vicinity of patients. Certainly, a global Tele-healthcare infrastructure is true need of the time. In this paper, we establish a Unified Tele-healthcare infrastructure that successfully addresses these challenges and other healthcare problems of modern times.

II. Problem Formulation

Traditional TFCs are not tailored to response real time requirement of remote patients. The answer is obviously the resource limitations in existing TFC infrastructure. The TFC in the concrete boundary walls requires that patient (from the location of incident) should be admitted physically, as soon as possible, in its observatory room. This admission is to avail optimized curing facilities from a city hospital (fully equipped with medical care equipment) situated geographically far away from the TFC [10]. It is important to note that TFC should always be connected by some means of telecommunication to city hospital in order to send patient data (mainly the vital sings) and to receive consultation from available medical specialist. Further, to perform any surgical job at TFC it needs post-analysis report of patient's vital signs, which may keep varying during an emergency [11][12]. For sake of simplicity, we preview the occurrence of tasks from the following flow-chart. The flow chart helps to understand the delay and risk involved before patient reaches under specialist monitoring with all physically present healthcare equipment. These problems are elaborated in the flowchart in Appendix-I.

The country-side establishments of TFCs require huge resources. More resources mean large financial numbers. Therefore, city hospitals and public safety organization use other resources (air/ water/ road carriages) to transport the effected masses to the nearest hospital in order to seek the best possible treatment. There are number of activities in existing TFC infrastructure that consume critical time of the diseased to settle him under complete care.

Refer to Fig. 1, another prevailing strategy in Tele-healthcare to minimize the idle time during transportation of the patient is the deployment of Mobile Medical Units (MMUs). The MMUs have proved partially helpful to address the challenge of initiating onsite first aid for effected people. It is fact that MMUs are not an alternate to city hospitals that are fully equipped with all necessary equipment. What we need for MMUs is a safe transportation of patient from emergency site to the hospital after any possible first aid [10]. These MMUs are, of course, equipped with some wireless broadband communication networks but have limitations like insufficient information about patient, e.g. medical history. A limited stock of useful gases is another constraint and every effort is made possible to reach at specialized monitoring environment at city hospitals. Moreover, the safe transportation of such an expensive and heavy mobile unit is not always guaranteed. Therefore, it is unrealistic that MMUs should serve everyone and everywhere [13][14].

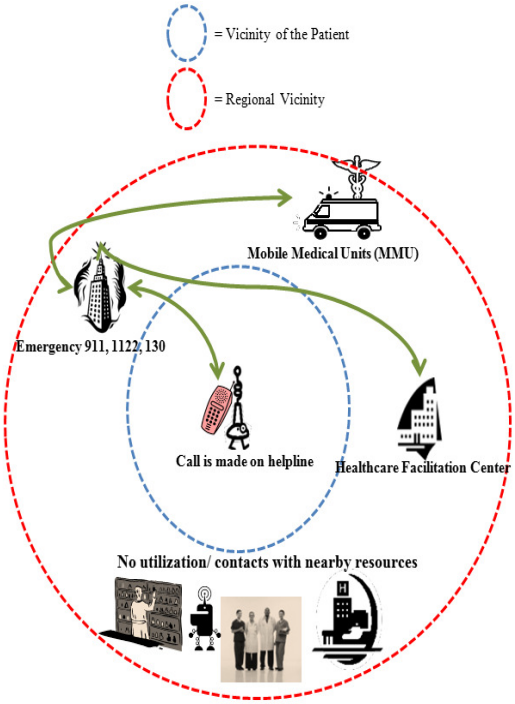

Fig.1 Traditional tele-healthcare network infrastructure during an emergency call

From the above study of traditional TFCs, we realize that problem of insufficient resources is inevitable and patient is solely dependent on the best utilization of time in the ticking clock of life. This is a convincing situation for researchers and medical specialists to admit that the discussed healthcare strategies are not optimized to save human lives at their best.

Now, we summarize our discussion about traditional Tele-healthcare challenges. "The traditional Tele-healthcare headquarters are unable to overcome the unavailability of onsite medical specialists, real-time monitoring by specialists, insufficient information about patient, the impact of continuously deteriorating condition of patient, non-networking among healthcare facilitation representatives (including doctors, regional health offices, drugstores, other public safety societies and additionally required manpower). The traditional Tele-healthcare systems are not tailored to meet different regional norms and hence, increase the response time during emergencies.

III. Prevailing Technologies for Tele-healthcare Challenges

Advancement in telecommunication and computer networks has sparked the R&D for growing needs for attentive Tele-healthcare facilitation infrastructures. Various new technologies have been proposed to meet current demands and future challenges of Tele-healthcare. From, Ethernet to Fiber Optic (FO), Radio Frequency (RF) to Free Space Optics (FSO) and from, cellular networks to Wireless Sensor Networks (WSN) or Hybrid Optical Wireless Broadband Networks (HOW-B), all of these technologies have their respective roles in Tele-healthcare infrastructure [1][13][14].

A literature survey of advancements in telecommunication indicates a progressive use of these technologies in Tele-healthcare infrastructures for monitoring remote patients. If Ethernet supports Tele-health systems in a limited area then fiber optics extends these services over a long-haul. If RF networks provide wireless freedom then FSO and HOW-B serve as backhaul in the development of hybrid networks comprising both, the RF & invisible optics (the high power laser). The use of cellular, ad hoc and wireless sensor networks in telecommunication and healthcare is also very important to make new TFCs smaller, smarter and more efficient to respond during any disaster [13][14].

WSN outperforms the conventional, unintelligent and standalone sensor systems that use larger and expensive technology (macro-sensors). Such macro-sensors require wiring and depend on their accurate onsite deployment. The human factor (concerned technicians) is also mandatory for smooth operations in such sensor networks. Wireless Sensor Networks have created new ways to develop reliable monitoring systems for patients that can immediately inform the occurrence of an emergency along instant health status and patient's location.

A common challenge for any new Tele-healthcare infrastructure is to face failure during an emergency. The natural disasters, failure of equipment, non-calibration and mishandling of medical or communication devices can crumble the communication links even before sending information about the occurrence of an epidemic disease or a disaster report of the affected areas. The autonomous deployment of communication system based on random wireless sensing nodes broadcast the communication and addresses this issue in a better way.

In the light of above discussion, the existing Tele-healthcare infrastructure should be highly stable, scalable and customizable to address future challenges as telecommunication technology is rapidly advancing; but this is not a reality, indeed!

In our strong opinion, the existing traditional Tele-healthcare infrastructure needs a critical review to minimize time delays during the procedural activities. Today, patients demand ways that may address their issues in a simplified way. We demonstrate here a Unified Tele-healthcare network (Uni-T-Net) to facilitate remote patient treatment in future. The Uni-T-Net takes into consideration the auto-generation of emergency signals and the arrangement of possible healthcare facilitation along a medical team formed on ad hoc basis within the vicinity of the patient. This leads to an immediate and authenticate treatment under specialist monitoring.

With the help of Unit-T-Net, we observe an improved coordination among healthcare resource (specialist, drug stores, medical equipment and other medicinal services). In fact, Uni-T-Net enables the Regional Healthcare Centers (RHCs) to trace, maintain, track and control healthcare resources. These RHCs also help to update the regional patient or resource information in global Tele-healthcare infrastructure of Uni-T-Net.

IV. The Proposed Unified Tele-healthcare Network (Uni-T-Net)

Here, we present a standard and symbolic representation to highlight the features of Uni-T-Net. We show that how Uni-T-Net is effective to meet the modern needs of patients. The discussion on traditional Tele-healthcare issues and advantages of Uni-T-Net over traditional healthcare structure is significant. Table 1 (below) contains the essential components, their names and related symbols.

A. Design and Working of UniTNet and Its Functional Components

As it is obvious that existing traditional Tele-healthcare infrastructure needs structure review, therefore, new research leads us to develop a system with immediate first aid treatment under specialist monitoring.

There are many reasons to bring patient in nearest modern hospital. These Reasons can be the real-time monitoring of signs and symptoms, various routine lab tests for blood to start treatment and to avoid treatment reactions, specialist availability, modern pharmacy and many others. During an emergency every resource is meant to facilitate patient onsite by giving an immediate and treatment or first aid. Residents of the health cautious countries are advised through different media to keep their wallet health-cards with them. Prevailing smart health-card is one example of integration of Medical and IT technologies that keeps the record of last visits (dates, time) by the patient to a consultant. The smart-card also contains information about blood and allergies. Hence, it is essential for an appropriate treatment (hospital care of first aid) that patient or doctor should have access to the medical history of the patient.

Our proposed Uni-T-Net facilitates the remote patient in a very careful way while solving various challenges to the patient as shown in Fig. 2 in (refer to Appendix-1).

In Uni-T-Net, the Uni-Module initiates the operation. The Uni-Module can be any generic hardware having integration of technology.

Unlike the traditional methodology, when sensor (in Uni-Module) reaches threshold of any vital sign of the patient it triggers two networks by itself, simultaneously. Wireless Sensor Network (WSN) being the first to broadcast the vital information about emergency to establish some peer-to-peer wireless sensor network with any Uni-Human or Uni-Doc in limited area. It is important to note that a patient may be unknown from his gradually deteriorating health (e.g. during a sleep) or may be unable to call for emergency help. Anyone who receives this message (SOS) from sensor network may call at Uni-Center (as a Uni-Human) or initiate treatment of the patient (as a Uni-Doc). A Uni-Module sample in Fig. 3.

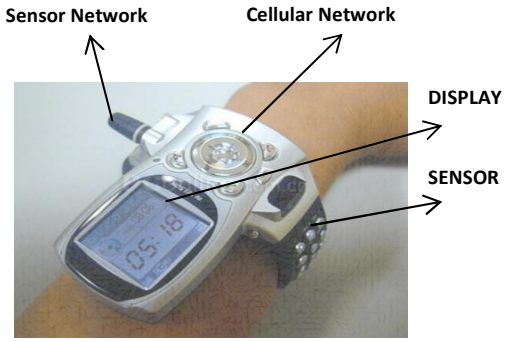

Fig 3. The Uni-Module: The proposed technology integration for global healthcare- the picture of cellular-watch (in display) is non-copyright and used as sample elaboration

The other triggered network uses available cellular networks on the site of patient. This SOS is generated for Uni-Center as having wider or global coverage with patient's location information (GPS). The User Identity Module (UIM) contains valuable information and shares it with Uni-Center. It is very valuable that still all procedures are occurring automatically. Referring to Fig. 2 again, Uni-Center (of patient's region) is capable to retrieve ID based health records and establishes contacts with all on-panel or registered Uni/ Non-Uni resources (including doctors, mobile units, volunteers, pharmacies and hospital) in the vicinity of the Uni-Patient.

Here, we face major problems like, to allocate unique global (regional) IDs and to access medical history about tourists, Internationally Displaced People (IDPs), and visiting foreigners form some other country where they live. For a complete solution, we propose to burn following information (Table 1) in the Uni-Module. We address this challenge by devising an approach to allocate unique IDs for globally registered patients (Uni-Patient) for the whole world. Uni-Center can retrieve then, medical history of the patient from respective Uni-Center of the region, where history of the patient is updated.

TABLE I. SAMPLE INFORMATION CONTAINED BY UNI-MODULE

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		
Description	Acronym	ID	Remarks
Country Code	CC	0092	PAKISTAN
City Code	CT	0000	Removed as not required (optional/ overload)
Gender	GR	0	0-Male; 1-Female
ID	PI	00-00-00-00-00	Maximum 1000Million female/ male for each country.
Age Group	AG	1	0-infant, 1-Child, 2-Adult, 3-Special (For DOZE selection)
Weight	WT	145	For humans*
Pulse Rate	PR	000	Vital Sign
Blood Pressure	BP	000	Vital Sign
Temperature	TM	00	Vital Sign
Respiratory Rate	RR	00	Vital Sign
Oxygen Saturation	SP	00	Vital Sign**
13 Digits Uni-Module/ Patient ID = xxxx-x-xxxxxxxx			
Uni-Module Information = CC-GR-PI-AG-WT-PR-BP-TM-RR-SP (xxxx-x-xxxxxxxx-x-xxx-xxx-xxx-xx-xx-xx)			
*More digits may be required to entertain animal community.			
**Special arrangements may be performed for such readings.			

Regional Uni-Centers are capable of fast data exchange between worldwide Uni-Centers. These are helpful for accessing treatment protocols of a patient, creating and monitoring new health trends with coordination of different societies while sharing and updating respective results of the patient. Individual global patient ID tied to health record gives a consistent availability of patient medical records. This is very important for ongoing treatment of the patient, especially migrants and those with long-term disease. This is unlike to wallet or smart health-cards that do not offer global access or acceptability.

The Uni-Module brings medical sensing capabilities, wireless sensor networks and wide range cellular networks to form an effective Healthcare infrastructure. We observe the Uni-T-Net with global scope for the humanity. The design of our proposed unified network exhibits the integration of modern technology to ensure the prompt and effective response to patient under any threat or damage.

V. Analysis of UniTNet

Healthcare systems face a number of tough challenges. Few of these challenges are increasing demands of citizens for safer and better quality of life, scarcity of health professionals, cost constraints and an ageing population. Thus, the government and Healthcare stakeholders including patients, doctors, and health care delivery institutes acknowledge that information and communication technologies applied to Tele-healthcare would have to play a key role for transforming traditional healthcare system into a global, highly scalable and effective modern structure.

Our proposed integration of technology leads the Unified Tele-healthcare Network to respond many of the tough challenges:

- Improving patients' safety with P2P-WSN: If a nearby doctor or specialist is present in the vicinity then a better care can be responded. The monitoring of the patient by a specialist suggests that first aid must be given without changing the position of patient which is likely an aid to patients' safety.

- Reducing avoidable accidents and medical errors with Uni-Module: Advanced wearable modules are present but need is to optimize the technology as Uni-Module to seek the best possible pre-treatment conditions.

- Efficient coordination between healthcare institutions with Uni-Database and UniCenters: Uni-Center serves as an efficient backbone enough to retrieve medical history of the diseased as well as sharing it timely. The contemporary technology of FSO (Free Space Optics) can play a major role as a backbone system for any ad hoc and sensor networks.

- Fast recovery with limited impact on quality of life (P2P-WSN): Development of under-skin sensors (and extended by WSN) makes it convenient to warn the nearby specialist or healthcare network about the location and condition of the patient. This may be monitored before a patient realizes symptoms of disease. Here, WSN can act as an early warning system in case of low-sugar level and exceeding heartbeats. It may even act like a curing/ healing assistant to the specialist at a distance by injecting a reserved amount of insulin into a human body.

- Increased emphasis on prevention (Uni-Database): The database can be used to generate alerts for any regional diseases using the Uni-Modules. The specific precautions can be shared with a patient by tracing his / her location from the global hub of Unified healthcare system.

- Increased citizen / patient empowerment and self-management (Uni-Module): Healthcare institutions may register themselves in Uni-T-Net. The Uni-Modules may help the patient to seek current health status, reports and details about other simultaneous changes in his/ her own body. Thus, he/she may consult to any Healthcare specialist in the network (WSN), if it is needed.

- Appropriate security and privacy provisions: The Uni-Module shall contact only (or generate automatic communication alerts in two networks) therefore making a patient's movement completely private. Further, Uni-T-Net should oblige the standardization of security issues to gain the confidence of clients. The unified Healthcare systems must be incorporated among Healthcare Institutes to avoid any exploitation of patients or patients' records.

- Protecting personal medical data from unauthorized access (Uni-Database): Some unified Healthcare Systems among institutes may allow the use of patients' personal data. In fact, the routine procedures for legitimate access in Uni-Database will be inherent; e.g. passwords, authentication keys, security certifications, etc.

- Access for medical personnel to up-date personal medical records (Regional Uni-Centers): This is pure policy-based and inter-institutional strategy. We recommend only the privileged access by Uni-Centers.

- Allowing for the best possible treatments, both in urban areas as well as in remote or underserved area (Unit-T-Net): With low cost, auto-alarming and features of global scope the Uni-T-Net is the only possible way (till date) to perform optimized treatments. It saves the cost of arrangement of medicinal resources and useless transportation of specialist/ patient. Further, it eliminates life-risk in transferring the patient to some nearby hospital for first aid.

Hence, we can predict that Uni-Module based Uni-T-Net is truly a globally effective healthcare solution for humanity.

VI. Conclusion and Future Work

Healthcare statistics from facilitation centers and medical insurance companies that health and safety measurements (including employee vaccinations and periodical checkups) has become a proactive strategy in both, the government and private organizations. However, during an emergency in congested metropolitan or remote hamlets the existing Tele-healthcare Facilitation Centers (TFCs) with network & communication facilities offer limited scope of patient care. The inevitable treatment delays in traditional Tele-healthcare infrastructure the patient's life goes under a great risk. These TFCs mainly based on private area network that offers limited interaction between remote patient and the doctor. To provide substantial medical treatment to remote patients (during early emergency hours), there is a need to review existing TFC infrastructure and traditional approaches. Here, we design a new infrastructure of modern Tele-healthcare as Unified Tele-healthcare Network (Uni-T-Net). The Uni-T-Net leverages the autonomy of interaction between roaming/ remote patient and the nearby doctor. Later it helps to take all possible measurement to quickly access the roaming profile of the patient and maintains a support from local facilitation centers which enables the doctor to take key decisions to cure the patient. We present an efficient approach that helps to generate and allocate patient IDs globally in an efficient way.

Uni-T-Net is customized to use available means of communications within the vicinity of the patient/ doctor. User Identity Modules (UIM) of Uni-T-Net helps to quickly deploy and broaden the level of medical treatment. The analysis of Uni-T-Net design, technology integration and performance of each of its components verify its scalability, customization and adaptive approach in different regions. Unlike traditional TFCs we idealize it to serve globally as Uni-T-Net and drawn diagrams for standard procedures. The main beneficiaries of the Uni-T-Net are roaming/ remote patients, tourists, migrants or Internationally Displaced People (IDP). We are confident that awareness with the Uni-T-Net infrastructure is helpful for governments and healthcare organizations to help and recover more endangered lives than traditional Healthcare networks may ever do. Our contribution to this world is to make it better and a safer place to live.

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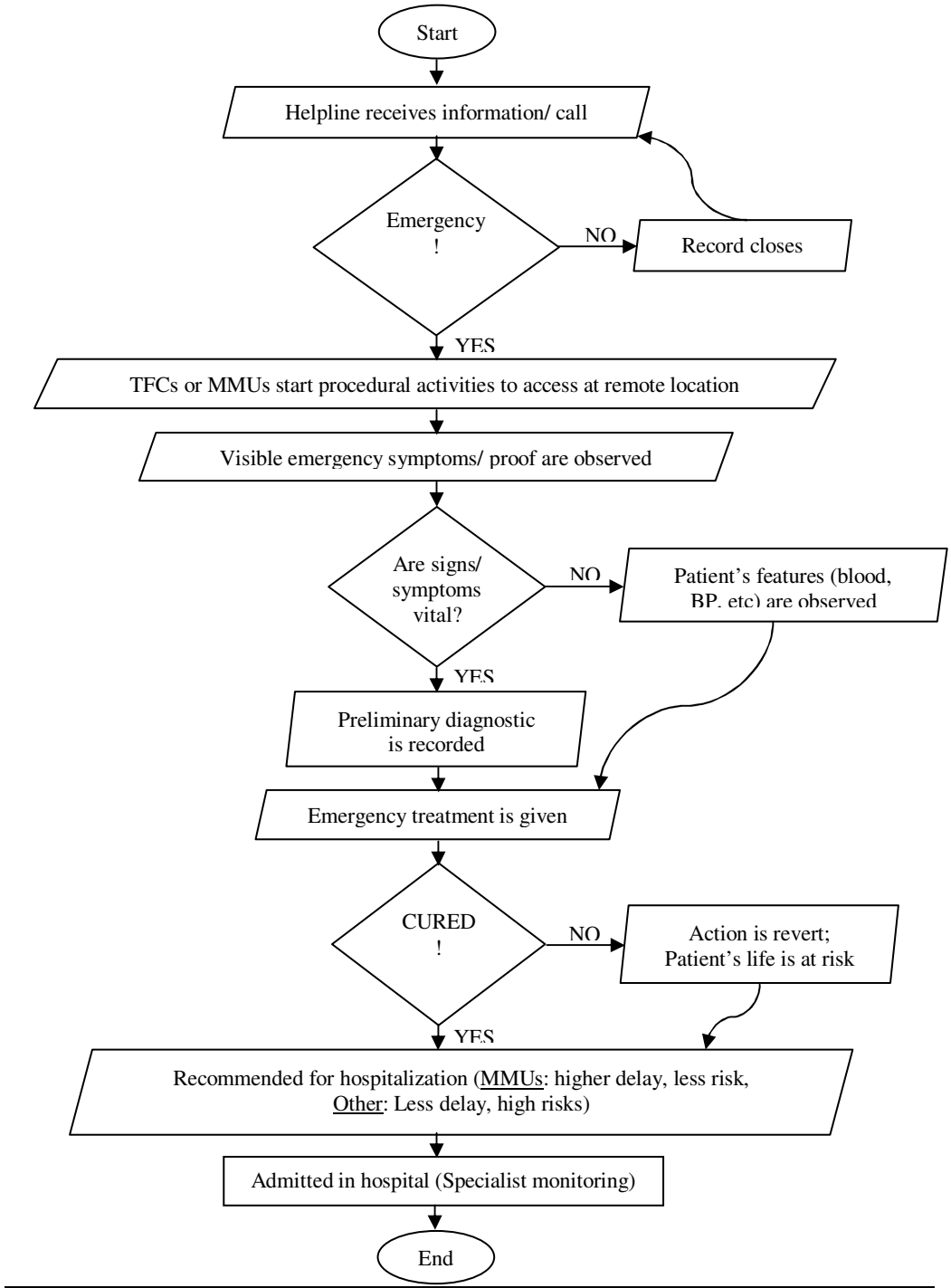
APPENDIX-I



Flowchart of the occurrence of tasks in traditional Tele-healthcare facilitation

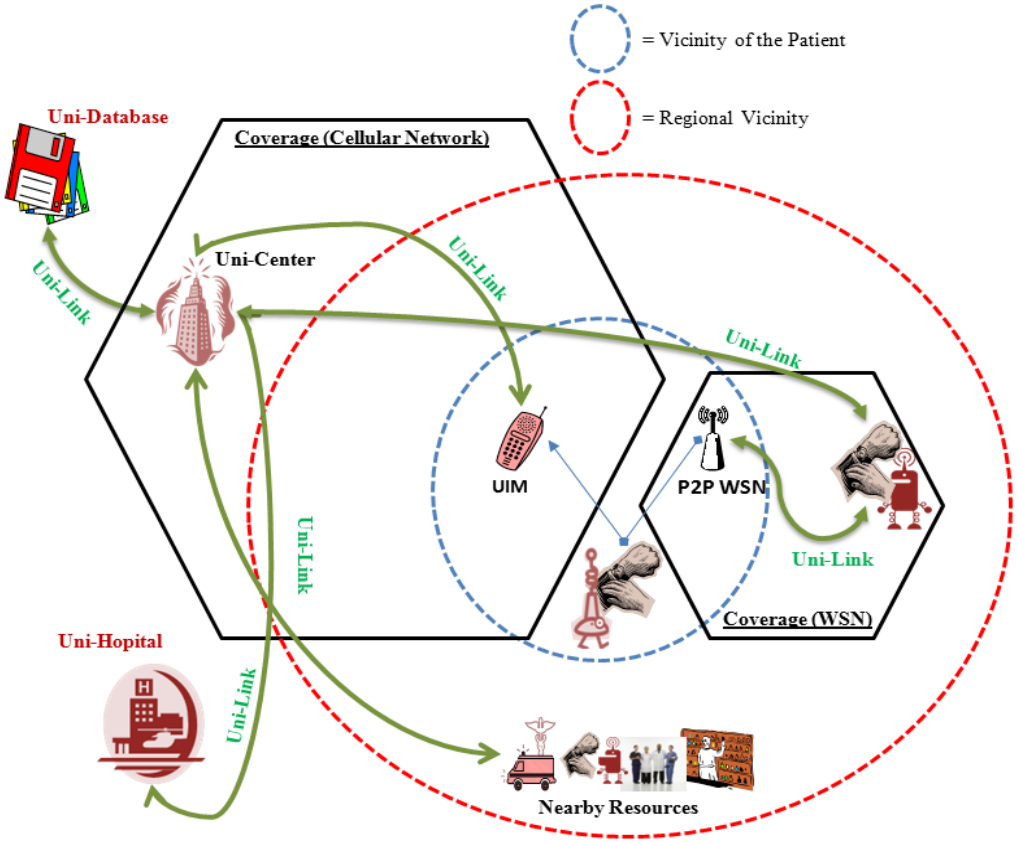


Fig. 2 Building blocks of Uni-T-Net and their interactions during an emergency call (using list of components defined below)

List-I Components (Traditional Tele-healthcare)	SYMBOLS
Tra-Hospital (Traditional hospital for Tele-healthcare)	
Tra-TFCs (Traditional Tele-healthcare facilitation centers)	
Tra-Doc (Traditional medical specialist/ team or mobile units)	
Tra-Human (Voyager, Business Travellers, Migrants, IDPs)	
Tra-Patient (Client of traditional TFCs)	
Note: Patient history can only be retrieved via wallet-patient-cards (paper based) or via smart-health-cards (accessible in hospitals only). Smart cards do not have global functionality. Animals do not have wallets or pockets to keep health cards.	

List-II Components (Uni-T-Net)	SYMBOLS
Uni-Database (Unified database stations of globally registered patients and specialists)	
Uni-Hospital (Hospital with support of RHCs)	
Uni-Center (Regional Healthcare Centers-RHCs: healthcare resources management)	
Uni-Link (any 24x7 link with additional P2P-Wireless Sensor Network)	
Uni-Doc (Unified medical specialist/ team or mobile units: nearby)	
Uni-Human (Uni-Voyager/ Business Travellers/ Migrants/ IDPs)	
Uni-Patient (Client of Unified TFCs)	
Uni-Module (Cellular, WSN, Display): Generic wearable device	
Note: Animals can also be facilitated if a parallel information system is deployed under Uni-T-Net is deployed during an emergency.	