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Mobile Health Services for Smart Cities

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Abstract*— Smart city utilizes information and communication technologies to provide comfortable living to its residents. Smart cities aim to improve the quality of healthcare services rendered to the patients, either through remote consultation or continuous monitoring of physiological data. Patient consultation or monitoring involves both communication and transmission of medical data between the doctor and the patient. Transfer of medical data is especially challenging since it is highly dynamic and contains valuable diagnostic information. Any alterations caused to the data, due to network operating conditions will produce potentially disastrous consequences in terms of patient diagnosis. So, medical data must always be transmitted on a network that provides good Quality of Service (QoS). In this context, a Patient Data Transfer (PDT) algorithm is proposed to identify the best network for medical data transfer in smart cities. The performance of the algorithm is tested for various medical traffic classes.

***Keywords*— Mobile health; Smart city; Network selection; PROMETHEE; Patient data**

I. INTRODUCTION

In the last decade smart cities have received increasing attention. The vision of smart cities is, to provide effective and affordable medical services to its citizens through remote consultation and or continuous monitoring of patient's data. This calls for efficient communication networks throughout the city that connect citizens to various healthcare and emergency services.

In India, mobile telephony network currently covers 90% of the population, and by 2017 it is predicted that there will be "more mobile phones than people" on the planet [1]. In such a context Mobile health (m-health) is an ideal tool to utilize the potential of mobile technologies for public welfare. Mobile health [2] is defined as the provision of health services and information via mobile technologies. M-health initiatives are broadly classified into, mobile surveys, surveillance, patient monitoring and treatment compliance. It involves the use of second, third and fourth generation networks along with smart phones, personal computers, tablets, pagers and sensors for communication between a health personnel and the patient. This article focuses on patient consultation and monitoring i.e. use of mobile technology to monitor and treat patient's ailment in a smart city. The monitoring process involves communication and transmission of medical data between the doctor and the patient.

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In the last decade, various m-health studies [3] [4], were conducted to discuss the feasibility of mobile technologies in providing health care to remote patients. In [5] the authors proposed a bandwidth reservation scheduling scheme that gives precedence to medical traffic over regular traffic. In most of the m-health studies [6-8], the focus is on the patient data transmission over an available network, with least consideration for QoS requirements of medical data. For effective diagnosis, medical data must always be transmitted on a network that provides good QoS. This article addresses the problem of network selection in medical data transmission.

Transfer of medical data is especially challenging since it is dynamic and contains valuable diagnostic information. Any alterations caused to the data due to network operating conditions will produce potentially disastrous consequences in terms of patient diagnosis. So, medical data must always be transmitted on a network that provides good QoS. With respect to networks, parameters such as bandwidth, delay, jitter and packet loss characterize the nature of QoS [9]. So, each network must be evaluated against multiple criteria to assess its QoS characteristic. This article proposes a Patient Data Transfer (PDT) algorithm, to identify the best network in terms of QoS requirements for medical data transfer. The core of the algorithm is Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) an outranking method. To the best of the author's knowledge, this is the first paper in the literature to focus on network selection for effective medical data transmission in smart cities.

II. METHODOLOGY

The key information components in medical data are audio, video and biosignals. Audio traffic includes diagnostic sound like heart beat and conversation between ambulance personnel and doctor. Video traffic comprises transmission of patient injury images. Biosignals are ECG, blood pressure, temperature etc. acquired from the patient. The biosignals will be picked up by the sensors connected to the patient and are inputted to the patient data transfer algorithm embedded in the smart terminal, such as a Laptop or a smart phone. The PDA algorithm identifies the best network as per QoS requirements

A Patient Data Transfer (PDA) Algorithm

Input

Input available networks
Input attributes values from each of the available network
Input current medical application
Input weights assigned to each attribute for various traffic applications

Execute:

Run PROMETHEE stepwise procedure [10]

Output:

Select the first ranked network i.e. the network with highest outranking flow as the best network

III. SIMULATION AND RESULTS

The simulation environment consists of a patient located in an area overlapped by four networks (LTE, UMTS and 2 WiFi hotspots). When multiple candidate networks are available for data transmission the PDT algorithm is automatically triggered. The algorithm is implemented in Java. The network QoS indicators at the time of assessment are shown in table-I.

TABLE I. Network QoS indicators

Networks	C	BW	D	J	NU	PL
WiFi1	1	6	43	6	80	30
WiFi2	1	44	95	17	70	18
LTE	1.5	7	45	10	70	09
UMTS	2	2	185	9	60	38

C: Cost (Rs), BW: Bandwidth (Mbps), D: Delay (ms), J: Jitter (ms), NU: Network Utilization (%), PL: Packet loss (per 106)

Weights represent the importance assigned to each of the attributes. Table-II illustrates the weights [11], associated with attributes for different applications climatic changes.

TABLE II. Weights assigned to network QoS indicators

Tele Medicine Traffic	C	BW	D	J	NU	PL
Audio	0.07	0.05	0.32	0.31	0.08	0.16
Video	0.05	0.38	0.16	0.06	0.21	0.18
Biosignals	0.07	0.24	0.06	0.05	0.18	0.38

Network ranking order generated by PDT algorithm, for various telemedicine traffic classes are shown in table-III. Audio traffic is mostly about instructions and conversation between doctor and ambulance attendant. It also includes heart sound, an important diagnostic parameter. For voice traffic, intelligibility suffices but there should be no transmission impairments in heart sounds. To satisfy requirements a network with low delay and jitter is required. PDT algorithm selected WiFi1network that has lowest delay and jitter when compared to other networks. So, selection ofWiFi1 is rightly justified.

TABLE III. Network ranking order for telemedicine traffic

Tele Medicine Traffic	WiFi1 (Rank)	WiFi2 (Rank)	LTE (Rank)	UMTS (Rank)
Audio	0.716(1)	0.399(3)	0.535(2)	0.231(4)
Video	0.303(2)	0.428(1)	0.289(3)	0.082(4)
Biosignals	0.533(2)	0.391(3)	0.613(1)	0.119(4)

To support good quality video stream a network that has large available bandwidth is required. In this context decision algorithm WiFi2 which is providing a bandwidth of 44Mbps on per user basis as the best network.

For bio signal traffic, packet loss and bandwidth are the decision influencing parameters. PDT algorithm selected LTE network having lowest packet loss and moderate bandwidth when compared to other networks. For the entire three traffic classes PDT algorithm selected the best of the available networks.

IV. CONCLUSION

In smart cities, mobile and wireless technologies have the potential to facilitate delivery of healthcare services to patients where distance is a constraint. QoS provision is a mandatory requirement when transmitting medical data, because of its relevance to the patient's health. Medical data must always be transmitted on a network that provides good QoS. In this article a PDT algorithm is proposed for identifying a QoS network for effective medical data transfer. Simulation results show that PDT algorithm identified the best network for all types of telemedicine traffic classes in terms of QoS requirements. Future work includes study of patient data transfer in energy constrained networks.

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