Chapter 111
Future Networked Healthcare Systems: A Review and Case Study

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ABSTRACT

Future healthcare systems and organizations demand huge computational resources, and the ability for the applications to interact and communicate with each other, within and across organizational boundaries. This chapter aims to explore state-of-the-art of the healthcare landscape and presents an analysis of networked healthcare systems with a focus on networking traffic and architectures. To this end, the relevant technologies including networked healthcare architectures and performance studies, Health Level 7 (HL7), big data, and cloud computing, are reviewed. Subsequently, a study of healthcare systems, applications and traffic over local, metro, and wide area networks is presented using multi-hospital cross-continent scenarios. The network architectures for these systems are described. A detailed study to explore quality of service (QoS) performance for these healthcare systems with a range of applications, system sizes, and network sizes is presented. Conclusions are drawn regarding future healthcare systems and internet designs along with directions for future research.

1. INTRODUCTION

The Internet is going through rapid changes. We are seeing fundamental developments in the Internet design and the whole Internet landscape through technologies such as content delivery networks (CDNs), overlay networks, Internet radio, Internet television, Multicasting, P2PTV (peer-to-peer TV),

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etc. Devices, applications and traffic profiles that internet is to support are on the rise. The Internet of Things (IoT) is driving the global adoption of IPv6. According to a 2011 report (Evans, 2011) by Cisco Internet Business Solutions Group (IBSG), the number of *things* connected to the Internet exceeded the world human population in 2008, the number almost doubled the human population in 2010, and it is predicted to reach 50 billion by 2020 with more than 6 devices connected to Internet per person in our world. These developments have the potential to transform and improve quality of life for all.

1.1 The Internet, Computing, and the Healthcare Industry

Cisco reports in a recent white paper (Cisco VNI, 2014), "Cisco Visual Networking Index: Forecast and Methodology, 2013–2018", 10 June 2014, that the global IP traffic has increased more than fivefold in the past 5 years, and will increase threefold over the next 5 years, surpassing the zettabyte threshold in 2016, reaching 1.6 zettabytes per year by 2018. Metro traffic will surpass long-haul traffic in 2015, and will account for 62 percent of total IP traffic by 2018. Metro traffic will grow nearly twice as fast as long-haul traffic from 2013 to 2018, due in part to the increasingly significant role of CDNs, which will carry 55% of Internet traffic by 2018, up from 36 percent in 2013. Global fixed broadband speeds will nearly triple by 2018, reaching 42 Mbps, up from 16 Mbps in 2013. IP video traffic (TV, video on demand (VoD), Internet, and P2P) globally will be 80% to 90% of global consumer traffic by 2018. Global mobile data traffic will grow three times faster than the fixed IP traffic from 2013 to 2018. Business IP traffic will grow by a factor of 2 between 2013 and 2018 due to the increasing adoption of video communications in enterprises.

The trends given above show a near-radical change in the Internet usage, applications, etc. and hence require fundamental changes in the Internet designs and appropriate deployment paths. Moreover, various industrial and government sectors, and other developments, such as transportation (see e.g. (TrafficLand, 2014)), healthcare (Microsoft, 2014), distance learning (Harvard Extension School, 2014), smart cities ('Smart Cities', 2014) are increasingly relying on the Internet for communications. Healthcare is now considered the largest global industry (McKinsey & Company, 2014) with an increasing ICT penetration rate. Big data and Internet of Things (IoT) are also set to drive radical changes in the healthcare systems landscape. The emerging technologies of big data, IoT, and broader ICT, in healthcare will enhance and accelerate the convergence between the activities of the healthcare professional and stakeholders, including patients, clinicians, administrators, healthcare providers, payers, researchers, and policy makers (Piai & Claps, 2013). They all try to coordinate their activities with the aim to provide personalized and preventive healthcare to patients, reduced healthcare risks, improve systems and operational efficiencies, and reduce healthcare costs. Patients particularly will benefit from this convergence because the healthcare data that they produce can help them in making more informed decisions about their health, preventing diseases and staying healthy. Moreover they can play a more proactive role in managing their health throughout their clinical pathways. Indeed with the emerging concepts in urban developments such as smart cities, a coordinated healthcare approach like the one described above can manage health for the whole society at city, country or global levels.

In brief, the future healthcare systems will leverage the technologies such as big data and IoT to provide personalized and preventive healthcare. It substantiates our view that the future healthcare systems and organizations will demand huge computational resources, and the ability for the applications to interact