Open User Interconnect and Quality of Communication

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Abstract—We looked for and found two situations within the South African Digital Divide where constant and severe macro-scale latencies would most likely interfere with the usage of Information and Communication Technology (ICT) solutions. We describe how these systems tend to exhibit both social and technical macro-scale delays. Our experience building bridges for these communities has inspired several innovations with respect to the design, development and measurement of IP communications systems. The main contribution is the Open User Interconnect (OUI) stack, a communications system model that explicitly includes the user in relation to the underlying network. The OUI stack is orthogonal to the Open System Interconnect stack. There are two outcomes from including the user in the model. First, the OUI approach necessitates the adoption of user-centred methods such as Participatory Design and in the case of the South African Digital Divide, the adoption of Action Research principles. The second outcome is a user-centred measurement notion, called Quality of Communication (QoC), that is a macro-scale spin on Quality of Service. QoC explicitly includes the measurement of user behaviour in addition to system metrics. In conclusion, we suggest that these Digital Divide-inspired contributions may be applicable to IP communications system design, development and measurement in general. The paper concludes with a brief dissertation completion plan.

Index Terms— Internet Protocol, Quality of Service, Semi-synchronous, User-centred design.

I. INTRODUCTION AND BACKGROUND

We looked for and found two situations within the South African Digital Divide where constant and severe macro-scale latencies would most likely interfere with the usage of Information and Communication Technology (ICT) solutions [4][6]. After contextualizing the South African Digital Divide, we describe how these systems exhibit both social and technical macro-scale delays. Our experience building bridges for these communities has inspired several innovations with respect to the design, development and measurement of IP communications systems.

The South African telecommunications and Internet environment exhibits both global and local aspects of Digital Divide. In our view, an important aspect of Digital Divide is the growing gap that exists between those who have access to the Information Society those who are deprived of such access due to shortcomings in personal capacity (such as handicap or illiteracy), cultural bias in applications and their content, lack of appropriate computer equipment, and/or access to network infrastructure. As a developing country, there is a global Digital Divide between South Africa and the developed world. Furthermore, within South Africa, there is a local Digital Divide between the haves (the few) and the have-nots (the many). Seen in this light, South Africa offers a peculiar opportunity to learn how to deploy Information and Communication Technology (ICT) to help bridge the Digital Divide.

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As an example, consider the *SoftBridge* built to enable a Deaf user with a PC to communicate with a hearing user on the telephone system [6][7]. In this case, the system incurs continuous repetitive latency in order to convert text-to-speech and vice versa. In addition, since Deaf users do not own PCs, they must travel (via public transport) to a community centre to use a shared PC. The delays therefore emerge from both technical and social sources.

We found similar, if not more extreme, mechanisms at work in a completely different scenario. We built another SoftBridge for rural tele-consultation that links a doctor and a nurse via WiFi in the remote Eastern Cape [4]. Regular extended power and network outages necessitate macro-scale communication delays. We also found that the overloaded schedule of the participating doctor introduces even more delay into the use of the system. In other words, no matter how well the system actually functions, external factors influence the usage of the system even more.

II. RELATED WORK

To deal with situations like this, we built SoftBridges with a store-and-forward, semi-synchronous approach to message delivery. This idea is not new. Email is perhaps the best example. Instant Messaging (IM) can also employ store-and-forward. However, to a user, IM can appear as either synchronous or asynchronous, depending on how it is used. Regardless, the macro scale delays in the store-and-forward application space are fundamentally different from the micro scale Quality of Service (QoS) in the IP and Voice over IP (VoIP) telecommunications space. In the VoIP world, latency and jitter are measured in milliseconds. Another metric, packet loss, also results in delay due to retransmission. In practise, QoS is most often characterised by these metrics, but there is also recognition that a user's perception also plays a part in the provision of "good" vs. "poor" QoS. [5] calls this "perceived" QoS, and the P.800 family of methods measure a user's perception by correlating quantitative subjective measures to QoS metrics [10].

There are also alternative views on QoS that further include the user. Both [2] and [9] stress *awareness* of the network, the former from the user explicitly, and the latter by providing application awareness of the network to influence a user's interaction with the system. Even though these views on QoS refer to the user, it remains the case that the Open System Interconnect (OSI) model does not include the user, but rather stops at the Application layer. In other words, the OSI stack links networks and applications, but stops short of including the user in its model of networked communications.

III. CONTRIBUTIONS

We therefore introduce the Open User Interconnect (OUI) stack orthogonal to the OSI stack as in Figure 1. The OUI stack consists of five layers that link the user to the network, namely the network itself, end-user devices, the human-computer interface, communication modalities, and user capabilities. One can consider the OSI stack to be embedded in Layer 1 of the OUI stack, or conversely, the OUI stack within OSI Layer 7. The primary innovation here is that the user is now *explicitly* included in the communications model. The OUI stack puts two interesting spins on system design, development and measurement.

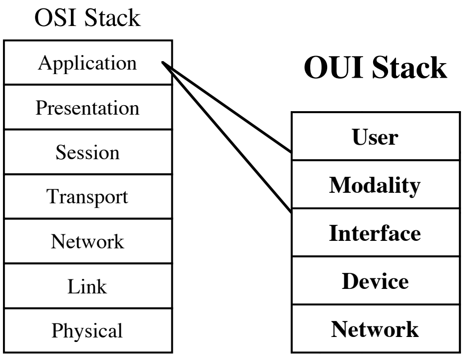

Figure 1: The OUI stack is orthogonal to the OSI stack and explicitly includes the user in the system.

Firstly, the OUI model necessitates the use of user-centred methodologies for system design and development. This is best exemplified by Participatory Design (PD) [8]. PD iteratively engages the user in the process and recognizes that the user not only knows what s/he needs, but can actually aid the system designer/programmer in realizing such a system via a series of prototypes. In our experience building systems for the South African Digital Divide, we have found this approach can suffer from a lack of "involvement" with the user to affect social change. Therefore, we broaden our user-centred approach to include principles of Action Research (AR) [1]. Our take on AR has been to initially engage a Human Access Point (HAP), or even multiple HAPs, as stakeholders in the overall cyclical process. We find that the HAP allows us to jump-start the prototype process, which can then be iteratively continued with the HAP(s) and a community to affect social change.

Secondly, the OUI model puts a user-centred spin on the notion of QoS, a concept we call *Quality of Communication* (QoC) that measures metrics within the OUI stack. QoC measures latency and jitter in terms of communication volley, rather than packet delivery. Thus, QoC granularity operates at a macro level. QoC measures *both system and user behaviour*. In some ways, QoC is inclusive of QoS, as the micro scale QoS delays can cause delays at the QoC level. Thus, QoS and QoC should be considered as complementary measures.

IV. CONCLUSIONS AND FUTURE WORK

This paper has introduced an innovative user-centred addition to the OSI model. The OUI model necessitates the use of user-centred design and development methodologies. The OUI model also enables a rethink of the notion of QoS to include a user's *behaviour* in the system quality measurement process. Temporal QoC metrics are similar to QoS metrics, but are oriented to a macro scale. The inspiration for this user-centred approach originates from building ICT bridges in the South African Digital Divide. However, it is important to note that the concepts of OUI and QoC are entirely universal, and apply to the design, development and measurement of communications systems in general because Digital Divide or not, the user's behaviour is the ultimate gauge of whether a system is useful or not. The best way to measure that is by involving the user in the design and development process, and by examining a user's behaviour as part of of the system.

This paper presents the theoretical foundation of a doctoral dissertation in progress. Additional work in progress involves fleshing out the OUI, QoC and SoftBridge concepts and the two applications of these concepts. Remaining work includes a detailed study of Instant Messaging with respect to OUI, QoC and SoftBridge concepts, the ongoing collection of QoC data for two field trials, and authoring the actual thesis.

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