Multihoming and Adaptive Multipath Transmission using off-the-shelf Components in Preclinical Medical Care

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In this work, we present a minimal protocol set allowing multipath transmission over multiple network providers for mobile clients in the context of mobile medical care. The system does not require any modification in the stack or the application and transparently transports any kind of traffic improving availibility, resilience and performance.

Over the past years, multihoming and multipath transmission are becoming an important capability of wide-area and datacenter networks for reasons of availability, resilience, and performance. Most telemedical applications are characterized by stringent real time requirements for data transmission, e.g. when transmitting a patient's vital parameters. In addition, these applications are often applied in mobile environments, e.g. ambulances or other first responder vehicles. Hence, multihoming and multipath transmission concepts constitute an appealing option to increase the reliability, capacity and speed of data transmission for such applications.

Exsisting protocols such as MPTCP or SCTP usually rely on significant modifications in both the operating system's networking stack and the application layer, it remains unanswered how and to what extent today's technologies may be used to achieve comparable results. Furthermore, waiting for reliable implementations of such protocols to become available, might delay the introduction of urgently needed new medical applications.

We define a minimal protocol set allowing multihomed devices in medical applications to communicate over multiple network connections. We evaluate the performance and applicability of a prototype system using existing components, i.e. features that are supplied by today's operating systems. By using a framework-approach, application developers can easily implement custom path performance estimation and path selection logic to optimize for application-specific requirements. Using an example in the field of medicine, providing medical first responders with reliable mobile network access over multiple 3G providers, we discuss the advantages of such a system in terms of cost-effectiveness, independence of standardization processes and deployability.

As the aim of our system is to improve reliability and quality of service of the first part of a mobile network connection (i.e. the part which is actually using wireless technology), we need access to the packet flow before sending packets onto the wireless link and when receiving packets from the wireless links to transparently forward them to their destination via the more reliable core Internet. Thus, the system consists of two integral parts, that is the client and a second entity we call gateway. The client application is deployed on a Raspberry Pi connecting client devices to the Internet, while the gateway is some publicly addressable computer which should be located somewhere closer to the network's core (figure 1). The client and the gateway bidirectionally probe multiple wireless links and distribute the packets based on some path-selection strategy over one or multiple of the in-

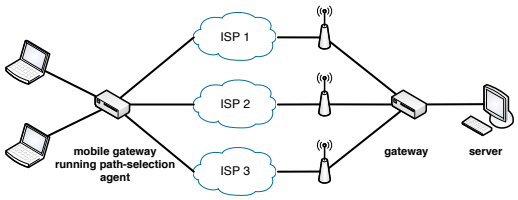

Figure 1: System Architecture

or outgoing links, respectively. By continuously monitoring packet delay and loss (and possibly other path properties), the agent decides what path is the *best* and sets the active path for data transmission adaptively in order to reduce packet loss or delay caused by lacking network coverage or insufficient network performance. This architecture exploits the concept of overlay networks as multiple tunnels are established between an end system and a tunnel concentrator spanned across different physical links

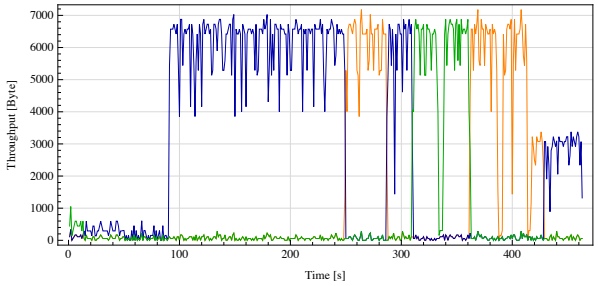

Figure 2: Path switching and throughput over three different wireless links

and possibly different independent wireless providers.

So far, the basic path switching functionality of the system was tested and evaluated using WiFi links showing fast adaption to failing links keeping the tunnel throughput on an almost constant level (figure 2). In the upcoming weeks the system will be tested using 3G adapters from different cellular providers. Additionally, different path selection strategies, as well as multipath transmission modes such as link aggregation or redundant multipath transmission will be investigated.