Support for Multi-Homing and Robust Delivery Services Within MobilityFirst Future Internet Architecture

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The Internet is quickly approaching an historic inflection point with mobile devices projected to far outnumber fixed/wired devices. The fixed-host model, the basis of network design since the Internet's inception, has resulted in architectural choices and protocols that have proven inadequate in supporting known and emerging challenges of mobile devices and applications. For example, the dominant Internet protocol TCP/IP, performs poorly under variable link quality and intermittent disconnection, which commonly occur in wireless access networks. Similarly, the difficulty for a single device to attach to different networks and simultaneously use them is an increasingly serious limitation. MobilityFirst [1], a clean-slate Internet architecture proposal, argues for several key design principles - quite different from today's Internet - to fundamentally address challenges of a predominantly mobile Internet.

In the demonstration described here, we highlight three design choices that address key mobility challenges and enable efficient and robust message delivery to multi-homed devices. They are: (1) separation of naming and addressing implemented via a fast global dynamic name resolution service (GNRS); (2) generalized delay-tolerant routing with in-network storage for packets in transit; and (3) hop-by-hop transport protocols operating over path segments rather than an end-to-end path. In MobilityFirst, a network object's human-readable name such as "Alice's laptop" is first translated to a unique network name - a GUID (globally unique identifier) - which is used as the long-lasting authoritative network identifier. Each attachment point is referred to by a routeable network address (NA), and the GUID to NA(s) mapping is maintained within the GNRS. The GNRS supports dynamic mobility simply by providing the current attachment (NA) of a mobile device.

Fig 1 depicts the routing of a message in MobilityFirst using a generalized storage-aware routing protocol (GSTAR) [2] and a hop-by-hop data transport based on the "Hop" protocol [3]. PDUs entering the network need only have the destination GUID, the authoritative routing information. At the first access router, the destination's NA is resolved by accessing the GNRS. Since resolution is available at each hop, dynamic rebinding to latest NA effectively handles mobility. Further, variable link quality and temporary disconnection is handled by using in-network storage at routers. GSTAR controls temporary storing of PDUs at routers instead of forwarding towards the destination during poor path conditions. A reliable hop-by-hop transport protocol is used to deliver PDUs between routers in contrast to the end-to-end reliability approach in TCP/IP.

In Fig 1, this dynamic binding ability is used effectively to enable *multi-homing* where a user's laptop may have two or more wireless interfaces (e.g., WiFi and 4G) on separate access networks, and the service objective is to deliver to one of these interfaces based on a suitable cost metric. The PDUs carry both these network addresses (post resolution) and the routing protocol implements a "longest common path" type algorithm before *bifurcating* the message to the destination(s). In making a decision a router can further consider end-host preferences as to what interface should receive messages. For example, a user may choose to receive delay-tolerant packets on WiFi, and delay-sensitive ones on the well-managed 4G network.

We demonstrate the above concepts and sample policies using a prototype of the MobilityFirst architecture that includes router and host elements. The Click-based router implements GNRS and GSTAR functions along with a hop-by-hop reliable link protocol. The host protocol stack is implemented on Linux and Android clients, with a new set of service APIs that correspond to the message delivery services. The demonstration will consist of several routers hosted on ORBIT grid testbed [4], emulating core and access networks with dual-homed hosts attached to this network through WiFi APs and WiMAX BTS. A content delivery application provides end-to-end data traffic to dual-homed mobile host. The experiment will demonstrate that the GSTAR protocol is capable of dealing with edge network bandwidth variation and disconnections. The protocol will also show it is capable of automatically choosing one or both available multi-homed paths in order to meet desired service and policy objectives. The multi-homed device in turn will see performance and robustness benefits of converged network access. Remote visualization of the network and application state from the experiment will provide insight into the concepts at work.

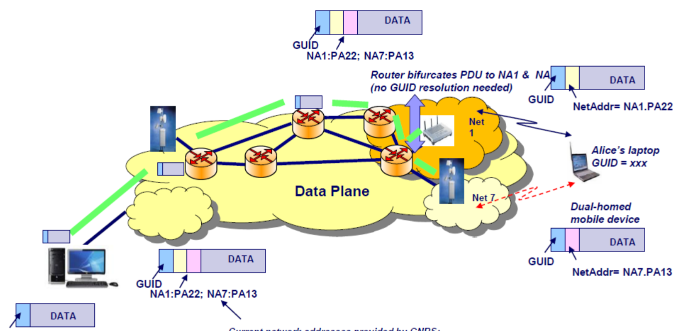

Figure 1: Message delivery to multi-homed mobile device

References:

[1] MobilityFirst. http://mobilityfirst.winlab.rutgers.edu.

[2] S. Nelson, G. Bhanage, and D. Raychaudhuri. "GSTAR: Generalized Storage-Aware Routing for MobilityFirst in the Future Internet Architecture." ACM MobiArch Workshop, 2011.

[3] Ming Li, Devesh Agrawal, Deepak Ganesan, and Arun Venkataramani, "Block-Switching: A New Paradigm for Wireless Transport", USENIX NSDI 2009.

[4] ORBIT Wireless Testbed. http://orbit-lab.org.

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