Demonstrating Information Centric Networking over Integrated Satellite/Terrestrial Networks

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Abstract— **The recent paradigm shift in the Internet's usage, from the host-centric communication model to a model where users request information irrespectively of its location, is coupled with an increasing need for converged and seamless access over heterogeneous wired and wireless (fixed, cellular, and satellite) networks. Using a satellite network emulator within a publish/subscribe Information Centric Networking (ICN) testbed, this demo illustrates key functionalities and gains when using ICN for integrating terrestrial and satellite networks, jointly exploiting the advantages of each: transparent use of terrestrial multicasting and satellite broadcasting, content-based multipath transfer, and seamless mobility.**

I. INTRODUCTION

The Internet's current usage is content-centric; the focus is not anymore on connecting end-hosts but on efficient content dissemination and retrieval transparently to the network access technology. In an effort to introduce content-awareness for more efficient control and delivery over content flows, various patches to the Internet's architecture have emerged (e.g. CDNs, proxies, Deep Packet Inspection (DPI)) which have progressively led to the ossification of the Internet. To address these needs, the idea of redesigning the Internet based on the Information-Centric Networking (ICN) paradigm has radically emerged. Explicitly routing on content identifiers, native support for multicasting, mobility and multi-source multi-path transfer are key ICN features that can bring the desired efficiency in content retrieval and dissemination over heterogeneous networks. At the same time, satellite technologies are long being exploited for wide area content broadcasting, while their potential is high for critical Future Internet application fields, such as Machine-to-Machine (M2M) services, and in geographic areas where terrestrial networks do not exist and are very costly to deploy.

Along these lines, the proposed demonstration aims to illustrate the gains of using a publish/subscribe-based ICN architecture for integrating terrestrial and satellite networks [1], jointly exploiting the advantages of each technology: Transparent use of terrestrial ICN multicasting and satellite broadcasting, native content-based traffic engineering by routers, multipath transfer (which allows bandwidth aggregation and offers resilience to link failures or to disconnections from one access network (for multihomed devices)), and seamless mobility. The first three are necessary to efficiently utilize network resources and provide robustness to failures, which is particularly important when the network consists of heterogeneous wired/wireless technologies with different capacities, costs and coverage, such as terrestrial and satellite links. Seamless mobility support is necessary for both vertical handovers in the case of physical mobility and horizontal handovers across different access technologies.

This demonstration is based on PSI, a Future Internet architecture defined by the PURSUIT project [2]. PSI follows a publish/subscribe communication model, aiming to decouple (i) data/service provision from its location, (ii) content resolution from data transfer, and (iii) routing and topology management from forwarding [3]. It enables content-based path selection and facilitates multipath transfer, native multicast and mobility support. PSI design builds on the separation of three core functions: Rendezvous, Topology Management and Forwarding (RTF). The *Rendezvous* function involves matching publications with subscriptions and initiates routing, forwarding and distribution decisions. The *Topology Management* (TM) function monitors network topology, detects changes and creates information delivery structures putting in effect policies and specific dissemination strategies. Finally, the *Forwarding* function implements information forwarding using LIPSIN [4]: Each link is assigned a forwarding identifier (FId) and the TM builds a delivery tree which includes such FIds. FIds are encoded in a Bloom filter placed in the header of each individual packet and used for forwarding decisions.

II. DEMONSTRATION TESTBED

The testbed that will be used for integrating ICN functionality in an integrated satellite/terrestrial networking environment (Fig.1) includes nodes running *Blackadder* [5], which is a prototype PSI implementation, and emulated satellite components. Blackadder implements the RTF functionality and is based on the *Click* modular router framework, exposing a publish/subscribe API to facilitate application development. We emulate satellite links using *OpenSAND* [6], a tool which implements real satellite DVB encapsulation (GSE/ULE, MPE, ATM/AAL5) and emulates lower layer protocols (MPEG2-TS, ATM, BBFRAME, GSE). It supports three types of nodes: Satellite Terminal (ST), Satellite Emulator (SE), and Gateway (GW). STs transmit/receive traffic to/from the emulated satellite. The SE emulates a transparent or regenerative satellite link by adding a preconfigured propagation delay. Finally, the GW acts as the central access point for STs and as the satellite NCC (Network Control Center), which monitors and controls the satellite network, and performs real-time time/frequency resource allocation.

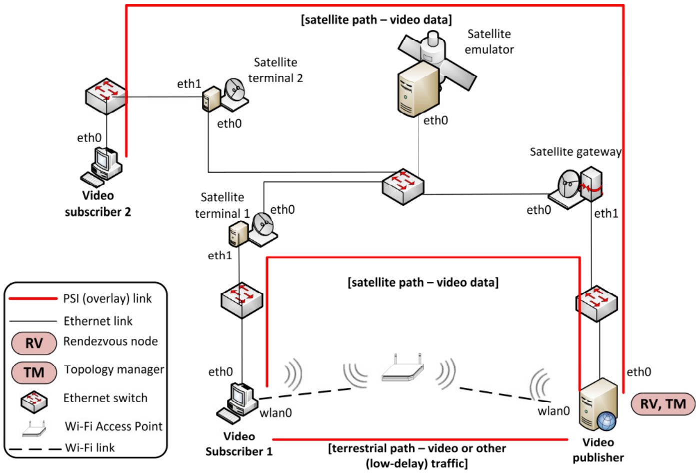

Fig. 1. Demo topology.

III. DEMONSTRATION SCENARIOS

A. Video streaming transparently utilizing terrestrial ICN multicasting and satellite broadcasting

This scenario involves video-on-demand streaming, multicasted from a single publisher (video server) to subscribers connected through a ST. The scenario demonstrates the inherent multicast capabilities of ICN: A delivery tree to all subscribers of a video is created and maintained based on the network topology. Using LIPSIN, forwarding elements do not maintain any state: The multicast tree is encoded into a Bloom filter carried in each packet and a simple AND operation is sufficient to decide if an incoming packet should be forwarded to a particular outgoing interface. The demonstration will show that receivers view the video without interruptions, while subscribers enter and leave the video streaming session. The ICN network transparently updates the multicast tree, by changing the corresponding bloom filter. Hence, the publisher (video server) is not notified, nor are the forwarding nodes affected, when new subscribers enter or leave. Finally, terrestrial ICN multicasting and satellite broadcasting are transparently and uniformly utilized: When a new subscriber is connected to the terrestrial network, ICN multicasting is utilized, whereas when the subscriber is connected through a new satellite terminal, satellite-based broadcasting is utilized.

B. Native content-based traffic engineering

The second scenario demonstrates an ICN network's ability to select and exploit multiple communication paths based on the type of content, but also on user preferences (e.g. considering communication costs) and operator policies (e.g. load balancing across satellite and terrestrial links). This is possible because naming of objects in ICN makes the type of content information available to the TM, which can implement various routing policies without requiring mechanisms such as Deep Packet Inspection (DPI) that would be necessary in legacy IP networks. Specifically, in this scenario video is streamed over the satellite link while interactive traffic requiring low round trip delay or control traffic is transferred over terrestrial links.

C. Bandwidth aggregation and resilience via multi-path delivery

The third scenario demonstrates ICN's ability to exploit multiple communication paths to fetch pieces of the requested content. Multipath delivery provides two significant advantages: Firstly, increased performance through the aggregation of bandwidth from multiple paths, and secondly resilience to link/node failures or disconnections from one access network technology in the case of multihomed end devices.

D. Seamless mobility

The fourth scenario showcases ICN mobility support. A mobile user subscribes to video content and receives it via his ST. Then, he disconnects from his satellite terminal's LAN and attaches to a Wi-Fi hotspot. We demonstrate that he is capable of receiving the video stream with minimal interruptions and service quality degradation, thanks to the multicast/broadcast capabilities of ICN: The user is pre-subscribed to the video stream from his upcoming point of attachment (Wi-Fi network). A new path (terrestrial) is added in the delivery structure by the TM and data are simultaneously forwarded to multiple subscriber locations. Service disruption and re-establishment delay are thus minimized as the user hands off. Note that mobility support does not require, e.g., changing of network addresses as in the case of IP networks.

IV. CONCLUSION

In this work, we have shown how specific features of ICN and satellite communication technologies can be jointly exploited in a converged Future Internet environment. The demonstrated application scenarios highlight the potential gains in terms of flexible multipoint delivery and content-based traffic management, but also enhanced mobility support.

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