

# The ASNE Taxonomy: a Case for Classifying the Multitude of Emerging Overlay Networks

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As the abundantly documented and discussed flaws of the TCP/IP protocol stack and its supporting infrastructure (Saltzer et. al., Stoica et. al.) [1, 2] became more and more prominent, the case for the use of Application Specific Networks [3] (ASNE, an acronym with a tenuous resemblance with the well-know ASIC) grew, gathering more and more user support. The idea of an ASNE is not new (Peterson et. al.) [4] and it can be seen as reasonable way of introducing new applications and/or functionalities in an already existing ecosystems of interconnected devices and users (i.e. a network). To alleviate or, more desirably, eliminate these flaws, several task forces started to discuss how to deal with the decoupling of the location/identification IP problem, the univocal identification of fine-grained objects in the Internet, security issues due to the appearance of several middleboxes [5] and many other practical issues related to end host mobility and multi-homing.

In practice, two main classes of solutions were proposed. The first suggests a global change to the current Internet, by demanding changes in or the complete replacement of the current routers and routing infrastructure (e.g. IPv6). The second suggests an incremental approach through the use of applications or other custom code on selected nodes that forms on its junction an ASNE. The study and the proposition of the principles of classification of ASNEs will be the main focus here, allowing the canonical and formal taxonomy for qualification of a set of current proposals/projects alongside with the correct identification of its associated objects: processes and users, nodes, network attachment points and paths (from Saltzer et. al.).

Based on Stoica [6] point of view, not only network overlays can be defined but also the underlay networks. The basic idea of this rudimentary taxonomy stems from the election of the IP layer (or in the OSI terms, the network layer) as the border for classification of an application specific network, built on a substrate network. Any network that operates using the IP as communication substrate will be qualified as an overlay network. Conversely, any network that has IP packets moved using any communication substrate other than the “regular” Ethernet (and with good reason one might argue about how arbitrary this definition is) in the link layer (OSI) will be classified as underlay network. As an example of an overlay network, the HIP (Host Identity Protocol) [7] can be cited, where the connections established between “host identities” (explained later in the text) are carried over the regular IP routing infrastructure (the substrate network). An example of underlay would be the Network Pointers [8], where the Ethernet layer is replaced by a modular “forward function” mechanism that allows nodes to use any form of access to the link layer to know the correct physical interface to which packets are supposed to be sent to.

In this sense, two orthogonal axis of the classifications of this taxonomy of application specific networks could be defined as follows:

- Regarding the layer: Underlay or overlay
- Regarding the purpose: Naming, Security, Mobility and Routing,

Two important points should be highlight here. The first one is the possible containment relationship between each “coordinate” of the purpose “axis”. It is expected that a routing overlay or routing underlay to have security and mobility capability, in addition to the required naming capability. Mobility overlay or mobility underlay on its turn, should also have security capabilities in addition to the also mandatory naming capability. It is noteworthy to reiterate that security and mobility capability are only “desired” functionalities for a routing overlay or routing underlay, while the naming is a mandatory one for any kind of underlay or overlay.

The second point to be highlighted is the possibility of expansion of the purposes or types of the application specific networks (i.e. the increase in the number of “coordinates” in the purpose “axis”) without any prejudice to the semantics of the taxonomy. The list of purposes of an underlay or overlay here chosen to form one of the axis of the taxonomy reflects the functionalities offered by the proposals analyzed in this text. Yet, adding, for instance a multicast underlay or multicast overlay to this taxonomy is allowed in a canonical way. A rich-featured taxonomy illustration will be presented in the complete version of this paper.

In this sense, an Overlay Network, as a particular instance of an ASNE, is a logical network formed by the aggregation of several selected nodes of a base (or substrate) network, providing in these nodes special common characteristics. In this manner while still physically belonging to the substrate network, the whole set of participating nodes will form, logically a new, overlaid network. Maybe the most prominent example of an overlay network would be the Internet itself in its early days: an overlay network of selected nodes (i.e. the computers equipped with modems) communicating over the telephone network.

Overlay networks, in consequence, add an additional layer of indirection/virtualization that brings more flexibility by incorporating these “advanced” capabilities (i.e. other than the existing) into an existing substrate network. As the example before illustrated, manually configured static overlays are nothing new. Several Internet overlays have been designed for many purposes, including providing OSI network-layer connectivity, easing IP multicast deployment, and providing IPv6 connectivity [7-12]. Overlay Networks frequently define naming, routing, and service model for communication between hosts and are designed to improve performance, functionalities and/or reliability.

In our work we have analyzed several ASNE proposals regarding their purpose, i.e., the functionalities they bring to the current Internet architecture. Following in the full paper version it will be presented a compilation of relevant articles in the suggested taxonomy. The varieties of project were mainly chosen based on their innovative solution, robustness or uniqueness. A detailed analysis will be presented in a future session for: HIP [7], i3 (Internet Indirection Infrastructure) [9], Hi3 (Host Identity Indirection Infrastructure) [10], Secure-i3 [6], TRIAD/WRAP (Translating Relaying internetwork architecture integrating Active Directories)[13], FARA (Forwarding directive, Association and Rendezvous Architecture)[14], IPNL (IP Next Layer) [15], SFR (Semantic-Free Referencing) [11] and Network Pointers [8].

Finally, a comparisons among these projects based on the generic communication taxonomy from Saltzer, on the new layered naming architecture from Stoica and on the HIP and i3 evaluation criteria from Gurtov [16] will be presented followed by a sub-session with a detailed comparative analysis table.

This paper is divided as follows: section 1 presents an Introduction that covers the main TCP/IP limitations that motivated this research and it is followed by a second session with a formal definition of the ASNE concept. In order to support the ASNE Taxonomy proposed in the third section, a detailed comparative analysis of several projects will be delivered as a fundamental basis for this discussion. Then a table of discussion based on the taxonomy suggested is presented in section 4 followed by a final conclusion drawn from the previous analysis.

## References

- [1] J. Saltzer, "RFC 1498 - On the naming and binding of network destinations," M.I.T. Laboratory for Computer Science August 1993.
- [2] H. Balakrishnan, K. Lakshminarayanan, S. Ratnasamy, S. Shenker, I. Stoica, and M. Walfish, "A Layered Naming Architecture for the Internet," presented at SIGCOMM, Portland, OR, USA, 2004.
- [3] J. Quaini-Sousa, M. A. d. L. e. Silva, F. F. Redigolo, T. C. M. Carvalho, H. C. Guardia, W. V. Ruggiero, and B. Ohlman, "Suitability of Overlays as a General-Purpose Data Communication Substrate on Gigabit Channels," presented at 18th IASTED International Conference on Parallel and Distributed Computing and Systems (PDCS 2006), Dallas, Texas, USA, 2006.
- [4] L. Peterson, T. Anderson, D. Culler, and T. Roscoe, "A Blueprint for Introducing Disruptive Technology into the Internet," presented at First ACM Workshop on Hot Topics in Networks (HotNets-I), Princeton, NJ, USA, 2002.
- [5] B. Carpenter and S. Brim, "RFC 3234 - Middleboxes: Taxonomy and Issues," IBM Zurich Research Laboratory 2002.
- [6] D. Adkins, K. Lakshminarayanan, A. Perrig, and I. Stoica, "Towards a more functional and secure network infrastructure," Computer Science Division (EECS), University of California, Berkeley Technical Report UCB/CSD-03-1242, 2003.
- [7] R. Moskowitz and P. Niklander, "Host Identity Protocol Architecture," January 2004.
- [8] C. Tschudin and R. Gold, "Network Pointers," presented at 1st ACM Workshop on Hot Topics in Networks, Princeton, NJ, 2002.
- [9] I. Stoica, D. Adkins, S. Zhuang, S. Shenker, and S. Surana, "Internet Indirection Infrastructure," presented at ACM SIGCOMM, 2002.
- [10] P. Nikander, J. Arkko, and B. Ohlman, "Host Identity Indirection Infrastructure (Hi3)," presented at The Second Swedish National Computer Networking Workshop 2004 (SNCNW2004), 2004.
- [11] M. Walfisha, H. Balakrishnan, and S. Shenker, "Untangling the Web from DNS," presented at 1st USENIX/ACM Symposium on Networked Systems Design and Implementation (NSDI '04), San Francisco, CA, USA, 2004.
- [12] D. Andersen, H. Balakrishnan, F. Kaashoek, and R. Morris, "Resilient Overlay Networks," presented at In 18th ACM Symposium on Operating Systems Principles (SOSP), Chateau Lake Louise, Banff, Canada, 2001.
- [13] M. Gritter and D. R. Cheriton, "An Architecture for Content Routing Support in the Internet," presented at USENIX Symposium on Internet Technologies and Systems, 2001.
- [14] D. Clark, R. Braden, A. Falk, and V. Pingali, "FARA: Reorganizing the Addressing Architecture," presented at ACM SIGCOMM Workshop on Future Directions in Network Architecture, Karlsruhe, Germany, 2003.
- [15] P. Francis and R. Gummadi, "IPNL: A NAT-extended Internet architecture," presented at ACM SIGCOMM, San Diego, CA, 2001.
- [16] A. Gurtov and A. D. Joseph, "Friends or Rivals: Insights from Integrating HIP and i3," presented at Workshop on HIP and Related Architectures, Washington, DC, 2004.