G-Lab Deep: Cross-Layer Composition and Security for a Flexible Future Internet

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Abstract. The Internet provides a global communication basis for businesses and communities. But in today's Internet new demands collide with old design principles, resulting in a complex agglomerate of protocols and patches. These makeshift solutions are hard to manage, protect, and extend. The G-Lab DEEP project aims at these challenges with an innovative composition approach with a special emphasis on security. One goal is the dynamic composition of functions from network and service layer based on the requirements of applications. The composition is done by a mediation process that selects suitable function modules and can negotiate whether functions should be positioned on network or service layer. In G-Lab DEEP a prototype for such architecture will be developed.

Keywords: Security, Functional Composition, Cross-Layer, Future Internet, Service Composition.

1 G-Lab Deep Project Description

In the current IP network design, applications and networks are inherently independent. Based on the separation of layers in the current network architecture applications are not able to instruct the network how to handle the applications' traffic (e.g. cannot request QoS or custom routing). The network only offers best-effort packet transport to the overlying applications. Additionally there is no standard way to tell applications the state of the network, so that applications could react and read the network status. Therefore one goal of a future Internet infrastructure is to support

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specific demands of applications plus the ability to inform them about the network status. The current paradigm of a layered model for networking is already partially broken up by some cross-layer techniques and a kludge of ad hoc solutions.

Besides incremental solutions for a future Internet new networking paradigms have been considered that follow a "clean slate" approach, i.e. disruptive technologies that develop the future Internet from scratch. One of these approaches is functional composition, which decomposes the network stack in functional building blocks and reorganizes the functionalities in a compositional framework. Functional composition focuses on the flexibility of the network and therefore targets two improvements to the current Internet

1) Ease of management and integration of new functionality
2) Application specific network composition and adaptation based on application requirements instead of using "one-size-fits-all" TCP/IP best effort service

The G-Lab DEEP project takes on the challenges of the current architecture with a modularized functional composition approach that 1) passes application specific requirements to the network layer and 2) uses a cross layer composition technique to allow composition of independent service and network functional blocks in one integrated framework based on the requirements and the network status. A modular solution with loose coupling is desirable to (a) achieve a clean separation of the needed functional blocks without strong entanglement of message passing functionalities, and (b) allow loose binding of functional blocks which are needed for a specific service or application request. Further this breaking down into atomic functional blocks allows for the most flexible combination of functions. This is desirable as each combination of services on the application level may require a different combination of network modules to support it.

In the application layer as well as on the network layer the same derived questions and problems arise for the composition of functions, for example the semantics, description, the management, discovering and the construction of the optimal function chain for the given conditions.

This concept can be visualized well using the example of voice communication in the Internet. The role of voice communication in the future Internet will grow, especially with mobile voice applications, while in parallel new functions are developed and new application requirements, many of them security-related, are evolving.

Consider for example the situation of an emergency call via a mobile voice terminal. Based on the specific user intent to make an emergency call a workflow of services within the service and network layer must be triggered which together form the emergency call. This workflow may invoke auxiliary services like “get location”, “make a call” and “reserve line” to support the nature of the emergency call. Maybe even a voice recording should be added automatically. Such auxiliary or partial services can be provided by service-enablers within the provider network.

While the emergency call is established functional blocks are invoked, but these must also react on requirements specific to this invocation (e.g. prioritization). Therefore the services as well as the network connecting them must treat the call accordingly. Within next generation networks (NGN) such requirements can be

passed along as policies. On the network layer we want to supply such features by functional composition of network blocks.

To secure a reliable provisioning of all of these network and service components, a management solution spanning those layers is needed, which must also include service monitoring as an integral part. This requires having the monitoring itself available on the service and on the network layer, with configuration and data export using standardized interfaces. The overall solution shall also work in an inter-domain environment. Monitoring can then be effectively used to detect anomalies and to trigger corresponding actions based on policies.

Through the introduction of a cross-layer monitoring system the network status is continuously monitored and made available to other network and application services. Based on this cross-layer monitoring service the composition engine becomes situation aware and can automatically compose services based on the network status. In the current IP world network attacks have become a tremendous threat. Besides threats to network elements and end-hosts (e.g. through virus and worms) there also emerged new threats with the development of new applications and services. Voice over IP has been exploited by adversaries for anonymous mass voice calls for commercial purposes (SPIT) and for passing the bill to other users or companies (toll fraud). Therefore the cross-layer composition and monitoring system needs to incorporate these experiences from the current Internet and address these challenges for future application to enable suitable detection and countermeasures in a secure way.

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