Inception to Application: A GENI based prototype of an Open Marketplace for Network Services

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***Abstract*—Choice-based network architecture enables users the power to choose services from a set of network service offerings from multiple providers within a marketplace. To facilitate marketplace alternatives and enable fine-grain service composition, a common service specification should represent a general-extensible design for describing a service. This allows users to discover, negotiate, and purchase network services from service providers using service advertisements in the marketplace. We have successfully developed a ChoiceNet prototype which rectifies some of the shortcomings of the earlier prototypes and demonstrates a contractual agreement between multiple network service providers to realize multiple end-to-end application scenarios using the common service specification within the GENI environment. Our implementation showcases the integration of two contrasting payment models for the procurement of contractual agreements for network services. Successful agreements results in the provisioning of the advertised network services. This demo helps in visualizing the network service life cycle as seen by the Marketplace.**

I. Introduction

In the journey from the ARPANET world in the 1960's to the Internet of the 21st century the network has evolved significantly. One of the major factors which has contributed in the popularity and success of the Internet of today is the plethora of services which are now available at the edge of the network. The invisible barrier which seems to be preventing the evolution of the core network (the backbone of the current Internet) at the same rate as the edge network is the lack of sustained innovation. One of the ways we can narrow the gap in the rate of innovation in the core and the edge network is through an "Open Marketplace" which allows for various stakeholders of the Internet infrastructure to be compensated for the innovation/reliability by the users of this infrastructure.

The concept of "Marketplace" is not new and has been around for sometime in several forms. The ones which the community of network researchers use widely for conducting experiments are PlanetLab [1] and GENI [2]. They might recognize these systems as federated network servers, but essentially its a list of network resources which have been pooled in the "Marketplace". PlanetLab and GENI is a step in the right direction, but we would like to take it further by moving from a federated network to a truly distributed network using a "Open Marketplace" which has a service abstraction schema inbuilt into it.

The ChoiceNet project describes the introduction of architectural entities into the Internet to enable fine-grain economic interactions [3]–[6]. These interactions occur within ChoiceNet's "Economy Plane", a plane that offers the presentation of competing services from various providers, the formation of contracts with each of these providers to satisfy a customer's service requirements, and the verification of performance between contracted services. Transactions occurring within ChoiceNet's "Economy Plane" would parallel real-world interactions that take place between service providers and customers. Contractual agreements are formed between service providers and customers using a defined set of ChoiceNet Interactions after some form of payment (or suitable consideration are exchanged) has been fulfilled by the customer. A successful payment results with a customer receiving a *token* of some kind. The token would be used to authorize access to a paid service within the "Use Plane". In this work, we would like to demonstrate:

- Using the service abstraction, construct a path service and a in-network service for an Open Marketplace
- The mechanism for decoding a service advertisement to determine the compatability of the service with other services present in a meta service
- A framework for plugging in payment mechanisms for compensating the providers of the service
- A working prototype within the GENI environment [2] which realizes the Open Marketplace

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II. Payment Integration

Customers must pay for an advertised service before they are allowed to utilize its service. To enable this, we have integrated our ChoiceNet implementation with payment transactions system using third-party electronic payment service's (PayPal and Coinbase's Bitcoin Testnet) sandbox environment. Each ChoiceNet entity maintains a payment portal, which can be used to interact directly with another ChoiceNet entity's associated third-party payment service. A successful payment results with the third-party payment service supplying a Transaction ID, which is later used to provide proof of purchase or outstanding commitment of service when requesting a token for service use.

The two contrasting payment services contain two different flows for exchanging funds from one account to another. In one sense, verification of the payment involves the presence of the funds in the vendor's wallet, which can be tracked using the shared Transaction ID for the service purchase. In the current implementation, services paid for using Bitcoins appear almost instantaneously in the vendor's (paid party) Bitcoin Wallet,

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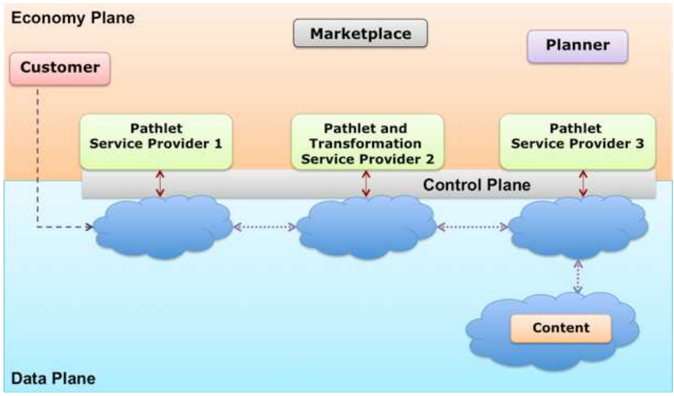

Fig. 1. ChoiceNet Demo Topology

allowing the user to quickly begin using their paid service. Bitcoin transactions can not be cancelled after being initiated, which is why the presence of a shared Transaction ID is sufficient for confirming the user's intent in making payment. Mishandled payment transactions requires the customer to communicate with the recipient for a refund. On the other hand, the integrated PayPal service requires the vendor to first confirm the purchase within a PayPal portal before the funds are transferred into their account. This additional step adds a degree of delay for users paying with this method, before a service token can be provided. Mishandled payment transactions can be mitigated using PayPal's internal service.

III. Demo Overview

Our prototype contains a deployment that fully realizes the formation of an "Economy Plane" contract and allows for the propagation of data within that contract's "Data Plane" resources, after a contract has been finalized. This prototype also allowed the verification of composition service. The prototype consisted of four service providers, a Marketplace, customer, and a third-party content server. Among the service providers, a single provider is solely providing a composition (planner) service, while the remaining providers demonstrate network providers offering pathlet services. An intermediate network service provider also offers transformation services, specifically substring-specific payload modification and packet logging. The topology for this deployment is illustrated in Figure 1. The goal for this deployment is to both validate that through using the current set of ChoiceNet Interactions, a customer could successfully send traffic through the network service providers to a connected content server and verify that our composition service could compile feasible service recipe with the given information in the Marketplace. To demonstrate the efficacy of the prototype, it is deployed on GENI with each of its entity and data plane resources within separate virtual machines.

In this demo, we present a scenario in which a customer is interested in accessing a content service but no individual service offering within the Marketplace can satisfy this requirement. The customer contacts a third-party Planner provider to discover if a composition of advertised service offerings can be made using the advertised services within the Marketplace. Several service composition recipes are compiled, priced, and presented to the customer for their choosing. Using this recipe the customer may begin purchasing each individual service from their respective providers.

Each network provider has a programmable Software Defined Network (SDN) switch, specifically LINC, attached that allows granular control over the network using an out-of-band third party controller software. When a customer sends a valid request to activate the provisioning of their service, the provider's economy plane agent sends the firewall specification (along with the valid token) to the SDN controller. The firewall specification describes some header parameters about the customer's traffic such as IP address. The controller assesses the specification and adds a corresponding OpenFlow rule based on the content of the specification. The time span of the rule is based on the expiration value of the token. The service provider offering a transformation service uses a simpler version of the External Processing Box (EPB) (discussed in detail in [7]) to perform the substring-specific payload modification and packet logging. Service providers advertise their suite of services within the Marketplace for customer to discover and potentially purchase. In this demo, we demonstrate an end-to-end scenario which uses a combination of contrasting services; pure transit services, transit services with payload modification, transit services with packet logging, and a transit service with both payload modification and packet logging.

By default traffic sent to a network service provider's "Data Plane" network prior to purchasing the service, are dropped by the network. Only after this interaction is successful and a firewall specification is supplied that appropriately matches the customer's traffic headers, will the traffic be allowed to traverse the provider's network.

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