Trust Management in Multi-Domain SDN Networks Using Blockchain

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Outline

In Multi-Domain Software-Defined Networks (MD-SDN) such as Internet (Fig.1), controllers communicate to provision end-to-end services across multiple domains besides enabling inter-domain routing[1]. Trust management across the domains provides operational feasibility, transparency, enhanced security and prevention of data abuse. However, quantifying and evaluating trust across domains with heterogeneous SDN implementations is challenging. This work aims to evaluate trust by enabling auditability across domains and builds a distributed trust management system for MD-SDN networks using blockchain. Blockchain allows a) to verify integrity of audit records b) tamper proof trust data storage and dissemination.

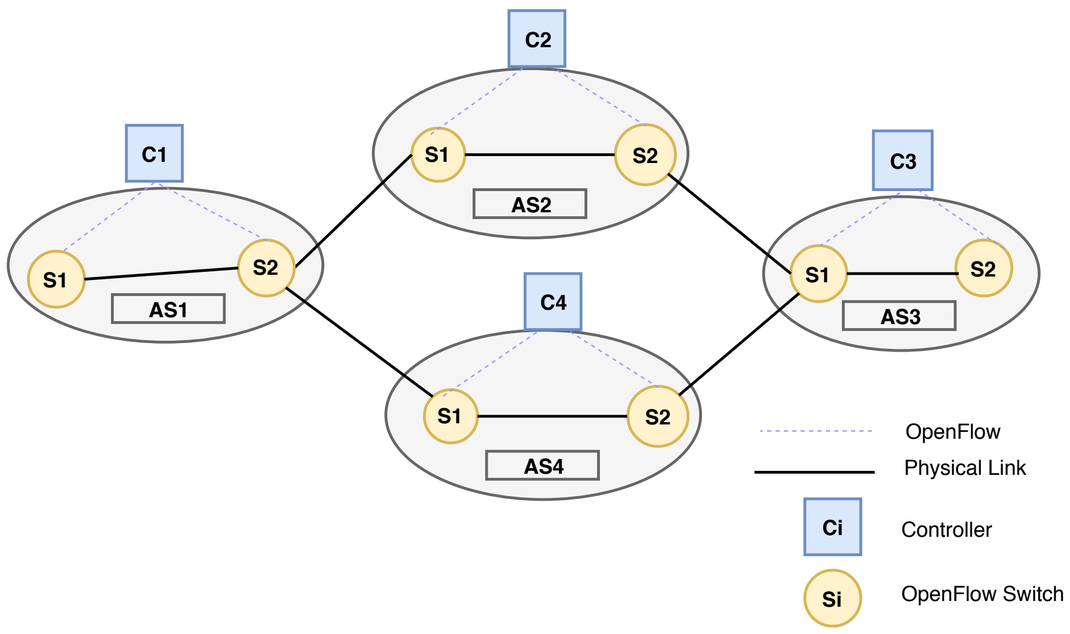

Fig. 1 MD-SDN Network

Background and Motivation

- Programmability of SDN offers flexibility for E2E service provisioning in MD-SDN networks[2].
- Information exchange between domain controllers are not verified (similar to BGP) to ensure integrity of exchanged messages.
- Finding trusted domains among multiple domains is challenging.
- Services with varying QoS values require different trust levels for SDN domains to collaborate.

Trust Management-Challenges

- Heterogeneity of SDN implementation across domains.
- Difficulty to quantify and evaluate trust between domains.
- Mechanism to build truly distributed trust management system.
- Handling collusions/fake trust values of domains.
- Tamper proof trust data storage and dissemination among SDN domains

Proposed Approach

- Trust Definition: Domain A trusts domain B, when domain B operates/provides the services in a manner that is promised to A.
- Evaluating trust by verifying audit logs from service provider domain controllers
- Building Trusted Controller Information Base(TCIB)
  - Exchange Domain Information Message(DIM) (xml/json message) during domain discovery process. DIM includes SDN deployment parameters and services offered with in a domain.
  - Hash of DIMs are verified through blockchain.

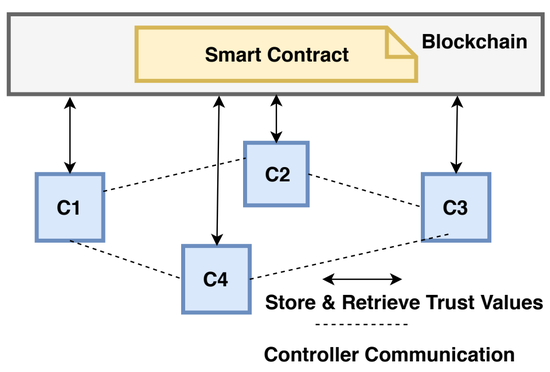

Fig. 2 Blockchain Controller Communication

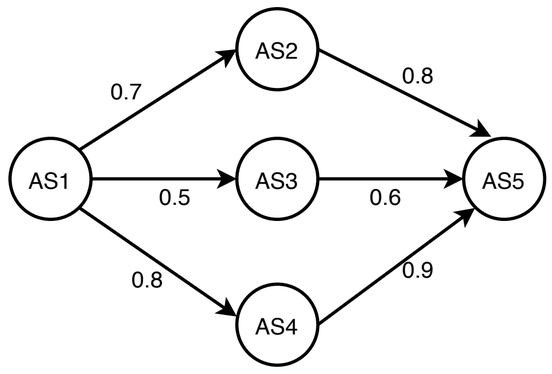

Fig. 3 Sample Trust Graph

- Service Profile Trust
  - Service Profiles classify distributed services with varying QoS. E.g., service profiles for video traffic delivery, virtual networks, service chains etc.
  - Identify (openflow) parameters for every service profile.
  - Negotiate parameters and obtain audit logs from collaborating domains for trust evaluation.
- Quantifying trust between a pair of domains for a service profile
  - Trust value is 1 if parameters conforms to expected (QoS) values, else 0.
  - Aggregated trust value calculated over a period of time, $(T_{agg}) = (m/n)$, m = successful interactions, n= total interactions.
  - Every domain controller puts T_{agg} of domains it interacted to blockchain.
- Trust management using blockchain
  - Smart contract is created to store and distribute trust values.
  - Trust graph (Fig.3) is generated for each service profile across all the domains and global trust is evaluated based on trust transitivity property.

System Design and Implementation

- To evaluate trust in a given domain D (Fig.4), the domain controller checks the TCIB for SDN deployment parameters of D and retrieves global trust value from blockchain.
- If D is trustworthy, the controller establishes a session and negotiates service parameters for auditing.
- Audit log retrieved from D is verified for evaluating trust.
- Our Implementation uses Ethereum, Solidity for creating smart contract, Mininet with Open vSwitches and RYU SDN controllers.

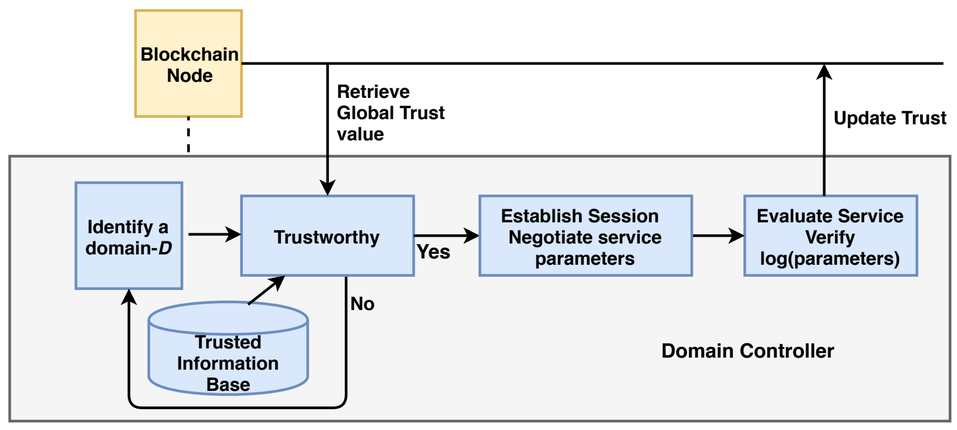

Fig. 4 Trust evaluation of a peer domain in controller

Current Progress and Discussions

- Developed testbed integrating RYU controller and blockchain(Fig. 2) and currently working on design of trust evaluation algorithms.
- Discussion points:a)Frequency of trust value updates to blockchain b)Missing trust values for a pair of domains in trust graph.

References

1. Zhou, Haifeng, et al. "SDN-LIRU: A lossless and seamless method for SDN inter-domain route updates." IEEE/ACM Transactions on Networking 25.4 (2017): 2473-2483.

2. Kotronis, Vasileios, et al. "Stitching inter-domain paths over IXPs."Proceedings of Symposium on SDN Research. ACM, 2016.