Discovery of Delay-Tolerant Networking Endpoint Elements

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In this thesis, we study discovery problems in heterogeneous networks. Internet applications generally involve contemporaneous low-latency connectivity oriented around hosts and addresses. The discovery standards, protocols and models used by these applications are focused on near real-time, low overhead, discovery of network information. These approaches are unsuitable as a generic solution to discover information that can be used to drive the process of message delivery in heterogeneous networks.

Delay tolerant networking (DTN) protocols support communications that are subject to link asymmetry, long propagation delays, disruption and packet loss. Anything used in DTN can be named in order to support heterogeneity, a major tenet of DTN. The DTN architecture uses endpoints, identifiers, and a wide variety of existing communications protocols for the opportunistic exchange of information.

There are several limitations of existing discovery approaches. Firstly, they do not have the scalability of loosely coupled systems. The majority of existing approaches feature discovery messages that are tightly coupled with underlying transport mechanisms. Such coupling means the structure of the information is specific to the infrastructure of the discovery mechanism. Furthermore, they mostly discover a subset of facts about a specific context. This might be reasonable in the constrained and secure environments in which web resources are typically deployed, but not for heterogeneous networks where it is necessary to decouple information from its producer in order to exchange it between different consumers or producers. We require the scalability of loosely coupled systems.

Secondly, they do not provide a generic solution. Existing approaches deal with context-specific aspects of discovery. They do not provide generically applicable information about structural and functional components of a system to work with network elements. Furthermore, their discovery messages are inflexible in terms of the discovery data and data structure. We require a generic solution.

Thirdly, existing approaches are based on a large number of assumptions. They assume how the discovery information is to be used, or configuration prior to conducting discovery. Approaches sometimes assume operator intervention, synchronous clocks or the ability to make a request. However, there may not be an operator or mechanisms required to maintain synchronous clocks, or align slot boundaries. Nodes might not have a complete knowledge of their context and might not be able to reach a consensus on how to behave, or even to request information. We need to an approach that makes as few assumptions as possible.

Finally, they do not offer explicit support for the discovery of network elements, i.e., offer laws that network elements can use to describe themselves for the purpose of discovery. Learning the presence of peers is not sufficient to facilitate informed decision making. Higher layer discovery is needed to correlate network elements. We need models capable of representing any network element to structure data, provide a portable representation for their transfer, and describe how to persist them to storage.

In this thesis we propose the Thing Discovery Protocol (TDP) and the TDP conceptual models that provide a node with the information to exploit an opportunity to communicate, in order to transfer ADUs. The hypothesis of our work is that a node can use our models to exploit a contact, in order to transfer more ADUs than a node using other models. The design of models to organise endpoint elements and attributes, in order to provide a heterogeneous network of associations, is the substantive contribution of this thesis to the area of DTN.

TDP can be used by DTN nodes to report their endpoint elements, attributes and identifiers. TDP, along with the TDP conceptual models, defines the methods for a DTN node to learn a description of the classes and relationships of its elements. DTN TDP things are associations of names with any element of a DTN endpoint that can be verified directly.

To evaluate our hypothesis, we have implemented TDP. Our evaluation demonstrated cases where nodes can use information provided by TDP to exploit contacts of the 2009, 2010 and 2011 Networking for Communications Challenged Communities (N4C) trial data, in order to transfer ADUs. It shows cases where in the event of a contact, data transfer applications, exemplified by "TDP-decider", can transfer more distinct ADUs than applications that use existing discovery protocols.