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HUMAN WORKING DAY MODEL IN DELAY TOLERANT NETWORKING VIA QUEUING PETRI NETS

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ABSTRACT

The project provides a systematic framework in providing such services. First, user behavioral profiles are constructed based on traces collected from two large wireless networks, and their spatio-temporal stability is analyzed. The implicit relationship discovered between mobile users could be utilized to provide a service for message delivery and discovery in various network environments. As an example application, we provide a detailed design of such a service in challenged opportunistic network architecture, named CSI. We provide a fully distributed solution using behavioral profile space gradients and small world structures recognition. This can improve the system performance and make the system more efficient by taking relevant samples. The objective of proposed system behavior-oriented services as a new paradigm of communication in mobile human networks. Our study is motivated by the tight user-network coupling in future mobile societies. In such a paradigm, messages are sent to inferred behavioral profiles, instead of explicit IDs.

Keywords: Delay-Tolerant net works, modeling, queuing Petri nets, performance evaluation, buffer dimensioning, bundle fragmentation

INTRODUCTION

The decision of forwarding a message to a particular node is made in accordance with a routing policy. The policy, especially in DTN, also specifies whether a copy is made locally before forwarding (replication of messages).DTN routing protocols circumvent intermittent connectivity using the store, carry, and forward mechanism wherein the nodes store messages locally and forward them as and when they come into contact with another node. Given the numerous use cases for DTNs and especially taking into account the limited computational resource at the disposal of most of the devices that are likely to find use for the DTN paradigm, it becomes critical to understand the routing performance of DTNs as a function of the physical parameters of the network and the participating nodes. An understanding of the DTN performance would enable one to make decisions pertaining to resource provisioning and designing routing policies while architecture a DTN. To the best of our knowledge, performance modeling of DTN routing protocols in the literature has seldom taken into account the realistic factors such as bundle fragmentation, buffer scheduling and buffer spacing**.**

We also show a case to exemplify the analytical capability of the QPN, by deriving the underlying reach ability graph and constructing an equivalent stochastic jump process. We identify the stochastic process to be a Semi-Markov Process (SMP) and hence arrive at a closed form expression for the end-to-end delivery latency by computing the hitting time of the SMP. We find that the model accurately captures the behavior of a DTN in numerous realistic scenarios, showing the efficacy of QPNs as a suitable modeling framework for evaluating the DTN routing protocols.

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RELATED WORK

We provide an exposition on the current state-of-the-art DTN routing performance modeling techniques and discuss their limitations as compared to QPNs. We also look at different instances where PNs have been used as a modeling tool to analyze distributed systems specifically ad-hoc networks. Each node computes a weighted average utility function that comprises the connectivity properties in the presence various degrees of selfish and malicious nodes. This bundle generation rate is same across the nodes. In this model, we focus on a typical pair of source-destination nodes. Since all node-pairs are identical, we argue that the model automatically scales for the entire DTN.

The Delay-Tolerant Network Architecture and Haggle are two interesting communication architectures proposed in this field. DTN consists of an overlay, called the bundle layer, which operates above the transport layer. The goal is to deliver data units called *bundles* from a sender to a receiver in the presence of opportunistic connectivity using different transport protocols assuming that nodes store, carry and forward bundles to cope with link outages. Haggle is an architecture for mobile devices that facilitates the separation of application functionality from the underlying network technology to provide seamless operation despite disruptions in network connectivity. It achieves this through late binding of network interfaces, protocols and names. It is thus different from DTN since it is not a strict protocol architecture but rather proposes a node design that allows nodes and applications to adapt to the network connectivity level. 7DS is another system for opportunistic dissemination of data among mobile devices and allows for extending legacy applications, such as web and e-mail, to opportunistic environments. Our system differs from systems in many fundamental aspects. It is data-centric with content-based addressing and it provides applications group-based communication via pub/sub interface. In contrast, DTN focuses on unicast source to destination communication and provides limited support for pub/sub communication. Haggle and 7DS are general purpose platforms to allow both new and legacy applications to operate in challenged environments while ours explicitly targets applications that can adapt to a pub/sub interface.

PROBLEM IDENTIFICATION

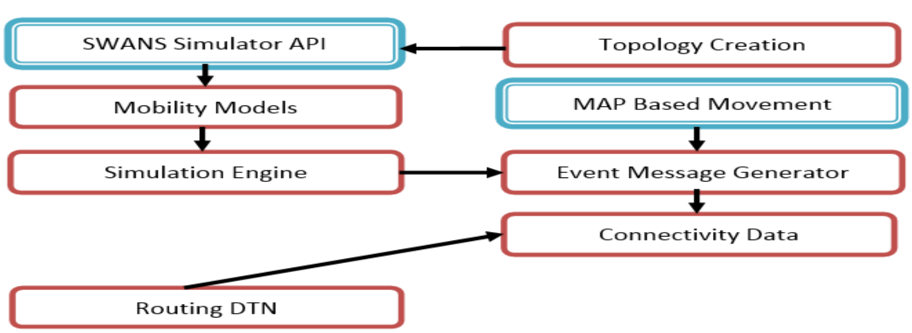
Here we try to understand the performance of DTN under realistic settings. A new methodology called Queuing Petri Nets (QPNs) as a modeling framework. Impact of various realistic limitations is studied. Experimental evaluation of the DTN on a test bed of android devices. We are trying to include an interference aware bandwidth model in DTN.

PROPOSED SOLUTION

We introduce the notion of multi-dimensional behavioral space, and devise a representation of user behavioral profiles to map users into the behavioral space. Our study is the first to establish conditions for stability of the relationship between campus users in this space. We propose CSI, a new communication paradigm delivering message based on user profiles. The target profile in CSI can even be independent of the context of behavioral profile we use to construct the behavioral space. We design an efficient dissemination protocol utilizing the stability of behavioral profiles and Small World in mobile societies, then empirically evaluate and validate the efficacy of our proposal using large-scale traces from university campuses.

Network Model

Fig1. Overall system flowchart for architecture



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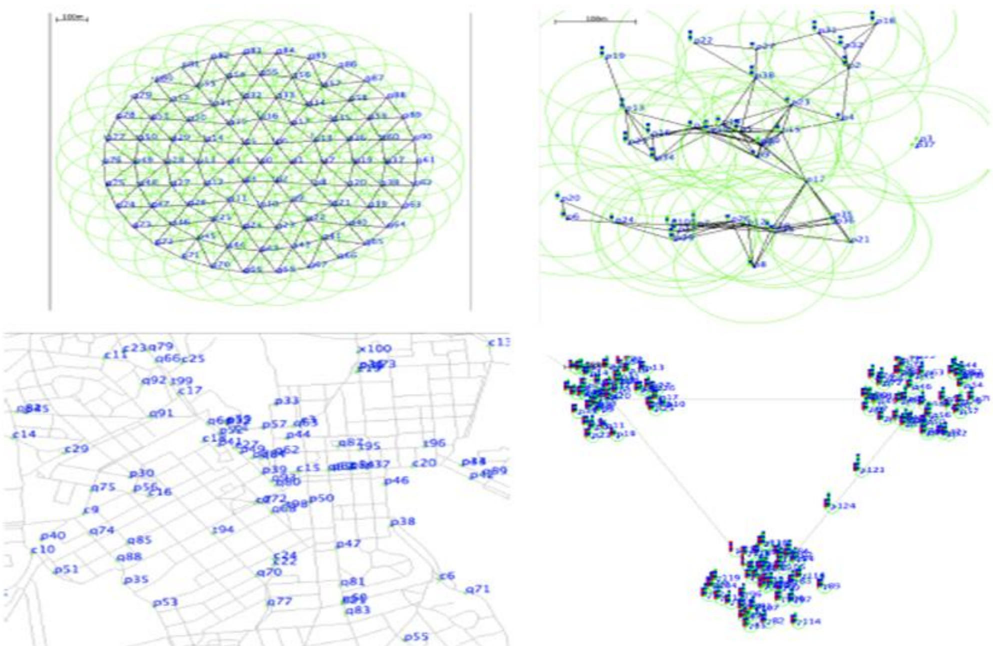
For the simulations, it is assumed that interpersonal communication between mobile users in a city using modern mobile phones or similar devices, using Bluetooth at 2 Mbit/s net data rate with 10m radio range. It is observed that WLAN radios with 100m radio range have only a minor impact and do not change the elementary interaction characteristics so that discussion is limited to the Bluetooth case. The mobile devices have up to 100MB of free buffer space for storing and forwarding messages (flash memory may mostly be occupied by music or photos.) There are 544 and 1029 mobile nodes (humans, cars and trams) referred to as small and large scenario, respectively which move in a terrain of 8300X7300 m. The area is either an open space (for simple mobility models) or a part of the Helsinki city area (for map-based movement). In addition to normal roads, several tram routes to the map is added. By choosing three different scanning intervals: 0 s which means that nodes are always on, 60 s and 300 s which mean that a node sleeps for the respective interval after losing contact with other nodes. RWP, As a baseline, the Random Waypoint Model is used with all nodes modeled as pedestrians moving at random speeds of 0.5 1.5 m/s with pause times of 0–120 s (both uniformly distributed) in an open space. With RWP, the space is slightly larger than for the other models because the rectangular shape includes those map sections which are covered by the Baltic Sea.HCS, A simple map-based movement model is the Helsinki City Scenario described above: six trams following predefined routes are used; two thirds of the remaining nodes are pedestrians and one third are cars. Cars run at 10–50 km/h and trams at 25–36 km/h with pause times of of 10–120 s and 10–30 s, respectively (all uniformly distributed). The pedestrians and cars choose random destinations in their reach on the map and move there following the shortest path. As earlier results showed that varying the numbers of trams and cars has some impact but does not change the basic communication characteristics, we stick to a single scenario.



ROUTING IMPLEMENTATION

The message routing capability is implemented similarly to the movement capability: the simulator includes a framework for defining the algorithms and rules used in routing and comes with ready implementations of well-known DTN routing protocols. This selection covers the most important classes of DTN routing protocols: single-copy, n-copy and unlimited-copy protocols, as well as estimation based protocols. Direct Delivery and First Contact are single-copy routing protocols where only one copy of each message exists in the network. In Direct Delivery, the node carries messages until it meets their final destination. In First Contact routing the nodes forward messages to the first node they encounter, which results in a “random walk” search for the destination node. State may also be attached to messages using a tagging

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mechanism and thereby routing information may be forwarded hop-by-hop across the network. For example, the Spray-and-Wait router uses this mechanism to include a copy count in every message. A message can be tagged with multiple independent values, or even data structures, that allow arbitrary routing, or any other, data to be transferred with them. When a simulation is run with the new routing module, the generic report modules gather the same performance data of the routing process as they do with the existing modules, so that comparing the performance of the new module to the existing ones is straightforward. In addition, it is possible to create routing module specific report modules that, e.g., read and interpret the data stored in messages with the tagging mechanism or query for parameters directly from the routing modules.

CONCLUSION

Propose a paradigm to represent, summarize and manipulate behavioural profiles and use such profiles as targets for the communication. We have presented a novel service of message dissemination in infrastructure-less mobile human networks based on the behavioural profiles of the users.We also observe that human behavior as observed in the large scale empirical traces is quite robust and only a few days' worth of data is adequate to summarize and leverage
accessing bundles from the secondary storage
at nodes on the overall performance. We constructed QPN models for DTNs of increasing complexity, starting from a network that employs the rudimentary direct transmission routing protocol to a powerful model that abstracts a DTN employing the family of *(p, q)*-epidemic routing protocols. We also performed an experimental three-fold validation involving simulation of the QPN, direct simulation of the DTN and experimental evaluation of the DTN on a test bed of Android devices employing a novel mobility emulation scheme. Moreover, we have also demonstrated the analytical prowess of the QPNs for a simplified (yet) realistic case of a DTN model (that involved practical parameters as limited link bandwidth and bi-level storage hierarchy).And this analysis was carried out by deriving the underlying reach ability graph, and computing the hitting time of the associated SMP. We found that the proposed models are able to accurately capture the performance of the DTN showing their validity apart from standing testimony to the modeling power of the QPN framework. While the analytical part of our QPN model assumes a DTN model with constant albeit finite bandwidth, in future, we plan to extend this analysis by including an interference aware bandwidth model that takes into account medium contention that is typical of wireless access protocols.

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