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Decentralized Resource Allocation in Mobile Networks

Patrick Lieser, Nils Richerzhagen, Tim Feuerbach, The An Binh Nguyen,
Björn Richerzhagen, Doreen Böhnstedt, and Ralf Steinmetz
Multimedia Communications Lab (KOM), Technische Universität Darmstadt, Germany
{firstname.lastname}@kom.tu-darmstadt.de

***Abstract*—Mobile devices are powerful tools for maintaining communication following disasters that affect critical infrastructure. In those post-disaster conditions, ubiquitous mobile devices can be used to establish basic ad-hoc communication in order to aid first responders or to organize volunteers. However, the energy of mobile devices is limited, and therefore the runtime of such networks is often insufficient to support the communication demand following a disaster. In this demonstration, we showcase the concept of the decentralized resource allocation in post-disaster mobile ad-hoc networks. Considering energy resources (e.g. car batteries, solar panels etc.) to prolong functioning of basic post disaster communication services, several cooperative resource allocation strategies are proposed as detailed in our accompanying conference paper [1]. Attendees can observe the behavior of mobile nodes competing for resources in an interactive simulation-based demonstration. By selecting allocation strategies and influencing the placement of resources and mobility of nodes, attendees can observe the effect of the different allocation strategies. In the demonstration the status of the mobile nodes and their actions to allocate resources are shown through live plots of relevant metrics.**

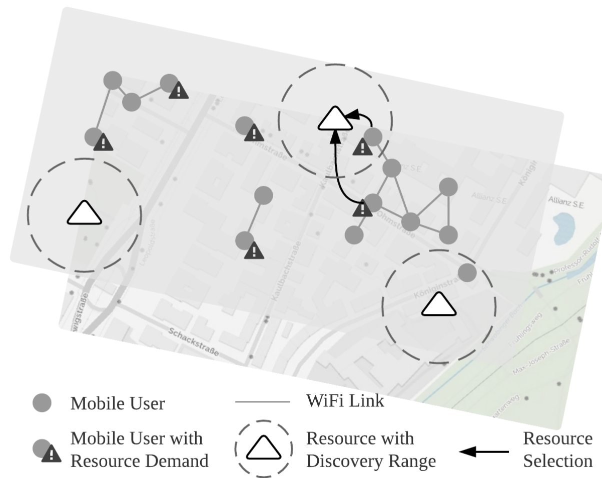

Figure 1. Entities in a post-disaster urban ad-hoc communication network. Physical resources can be discovered and consumed by mobile nodes that communicate via Wi-Fi. Adapted from [1].

I. Introduction

Exceptional events such as large-scale blackouts [2] or natural disasters such as hurricanes or earthquakes increase the demand for communication significantly [3]. At the same time, communication infrastructure is rendered unusable [4], often as a consequence of impaired energy infrastructure. To provide means for communication in such scenarios, ad-hoc and delay tolerant networks for disaster communication services have been proposed by the research community [5], [6]. The performance and utility of these approaches are strongly dependent on (i) the number of participating mobile users and (ii) the available battery capacity, given that no energy infrastructure is available and nodes are going offline as soon as they run out of battery. Using external power sources, such as car batteries, the lifetime of individual devices as well as the communication network can be prolonged.

Therefore, we propose a decentralized resource allocation service in [1], enabling mobile devices to coordinate the consumption of available resources. We contribute different allocation strategies and study their performance and utility cost. To the best of our knowledge, our work constitutes the first approach that considers the allocation of external power sources in a fully decentralized fashion.

In this demonstration, we enable attendees to interact with the service by switching resource allocation strategies and by further influencing the available resources and node behavior. Attendees can observe the resulting behavior from a birds-eye perspective through our world view showing the simulated area as illustrated in Figure 1. Additionally, relevant metrics such as the number of online clients, their current state, and the number of available resources are displayed as live plots during the demonstration.

We provide a brief summary of our decentralized resource allocation service for disaster scenarios proposed in [1] in the following section. Section III details the demonstration scenario and setup, highlighting the interaction possibilities.

II. Decentralized Resource Allocation

Figure 1 shows the considered scenario for the demonstration. Nodes which are within the communication range of a resource, discover it and can optionally share information about this resource with their neighboring nodes. If a node has demand for a resource, the node's resource allocation client decides which resource to select and the node starts heading towards it.

Figure 2 displays the different components of the resource allocation client which are listed in the following:

The *Demand Evaluation* is determining whether a node currently has a demand for a resource or not. For example this demand event can be triggered by the user itself or when the current energy level is below a certain threshold. A *Cost Mapper* is used to assign each known resource, stored in the nodes *Resource Storage*, an individual cost. Using the *minDistance* cost function for example, the cost for a resource is calculated based on the distance between a node and a resource. This mapping of individual costs for different known resources is then used by the *Selection Strategy* that decides whether to compete or not to compete for a certain resource. Based on this decision the node changes its consumption state.

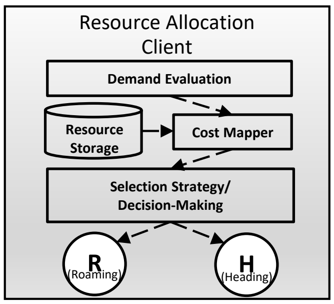

Figure 2. Nodes resource allocation client.

A node can be in one of three resource consumption states as displayed in Figure 3. They begin in ROAMING state in which they follow their personal movement policy. In this state, the node's current energy level c_e is reduced by E_r per second. If c_e is zero, the node stops its movement and communication then changes to OFFLINE state, from which it cannot recover. If a node wants to recharge at a resource, it enters HEADING state consuming E_h resources instead. We require $E_r < E_h$ to reflect the additional energy usage by the phone's screen and GPS component required for navigating the user towards the target. As a consequence, heading for an already depleted resource results in not only wasting the user's time but also the device's valuable energy.

Nodes return to ROAMING state either after arriving at the resource or if the *Selection Strategy* decides that pursuing the target is no longer worthwhile. Nodes try to maximize their own profit by transferring as much energy as possible from a resource, up to their maximum capacity e_{max}.

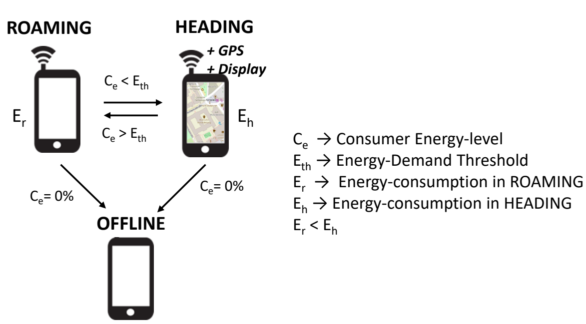

Figure 3. Mobile nodes resource consumption states.

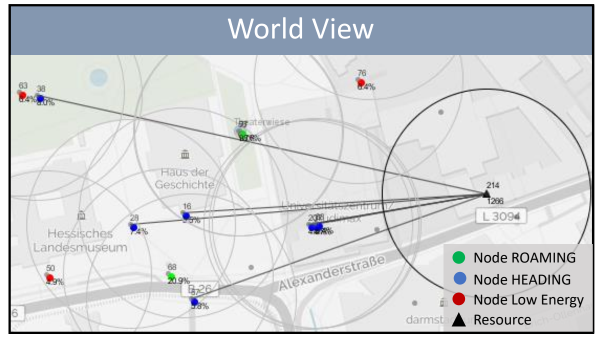

Figure 4. World view visualizing the scenario and its entities.

III. Demonstration Scenario and Setup

We demonstrate the aforementioned resource distribution service in an interactive simulation relying on the SIMONSTRATOR platform [7]. The simulation relies on the social mobility model proposed in [8], with mobile nodes following pedestrian walkways in an urban scenario based on OpenStreetMap data. Nodes select potential target locations out of a set of attraction points modeling points of interest in the real world. Such points of interest comprise public parks, market places and other spaces of interest in an urban setting. Each mobile node has the ability to communicate via Wi-Fi ad hoc with other nearby nodes to spread information about known resources or results of the decision-making process. To assess the lifetime of individual nodes, each node starts with a realistic energy level according to [9]. This energy is then consumed depending on the current node state (ROAMING, HEADING & OFFLINE).

The mobility of nodes, the available resources, and the current node state is visualized in the *world view panel* as illustrated in Figure 4. If a mobile node is actively targeting a resource in the HEADING state, the targeted resource is clearly marked. The world view aids in asserting the impact of different selection strategies from a birds-eye perspective, showing the overcommitment of the available resources as well as moments when nodes stop their attempt (changing their consumption state) or head to another available resource.

A. Interaction with the Demonstration

To enable attendees to interact with the simulation, we provide a second screen showing the *interaction and results panel*. Using this panel, attendees can directly obtain detailed information about individual nodes in the system (such as the current battery level, their state, and known resources) and, thus, follow the decision making process outlined in the previous section. In addition to these node-specific information, the panel provides aggregated metrics for the whole scenario as illustrated in Figure 5. This includes the number of nodes with energy, the amount of energy available in the system, and the capability of the network to support disaster communication. Attendees can directly influence a number of simulation parameters, such as current mobility characteristics, the available resources and their placement, as well as the utilized assignment and selection strategies. Thereby, attendees can explore the benefits and potential drawbacks of the proposed decentralized resource allocation service for disaster scenarios in an interactive setting, going beyond the scope of the main conference paper [1].

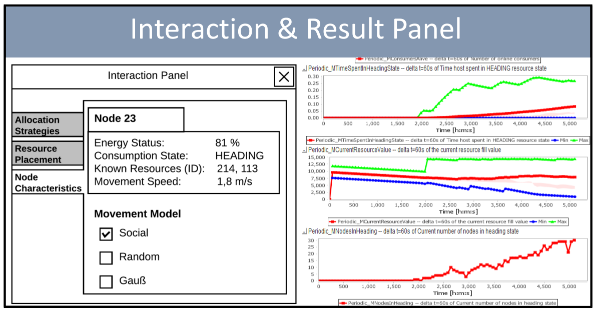

Figure 5. Interaction and result panel.

IV. Conclusion

We believe that the proposed demonstration helps in understanding the challenges for decentralized resource allocation in mobile networks and enables exploring the proposed resource allocation service that can support and maintain communication in disaster scenarios. The ability to interact with the system poses a valuable addition to our main conference paper [1].

V. Technical Requirements

The necessary equipment for the demonstration contains a laptop and a monitor. The monitor is used to show attendees the world view of the simulated scenario, demonstrating the node movement and decision-making process. The laptop monitor is used for the interaction and result panel, showing the live plotting of different evaluation metrics. Additionally the user can interact with the simulation configuration, allowing them to switch between different resource placement and resource allocation strategies, allowing them to explore the advantages of cooperative resource allocation strategies. We would kindly ask the conference organizers to provide us a computer monitor (22-24" with HDMI connector) and two power outlets. Demonstration setup will need 20 minutes.

Acknowledgment

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