Reference Models and Related Business Cases for Ad–Hoc Networks

Frank Fitzek, Patrick Seeling
acticom GmbH – mobile networks
R & D Group
Am Borsigturm 42
13507 Berlin, Germany
fitzek@acticom.de

Martin Reisslein
Arizona State University
Department of Electrical Engineering
Arizona State University
reisslein@asu.edu

Abstract

In this paper we outline our future research activities in the field of ad–hoc communication systems for IP based services by showing several reference models. We will give a brief introduction to the motivation of evaluating different scenarios and give a brief description of their application in an exemplary business case. All related reference models assume that each ad–hoc cluster contains one bridging entity realizing the access to the IP network. Models without such an bridging entity are out of the scope of the paper.

Keywords: ad–hoc networks, business cases, ad–hoc scenarios, reference models

1 Motivation

As the utilization of wireless networks for serving the networking needs in various hot–spot scenarios seems to emerge from the planning state into broad application, we consider a more theoretical view of different deployment scenarios as needed. In order to provide a sufficient access of wireless terminals to an IP backbone, for various different settings different approaches of connection and communication seem to be more favorable than others. We will outline some scenarios and present an exemplary business case of applying the theoretical setting into usage.

2 Generic Setup

The basic units that are of concern are the wireless terminals (WT) that always need to connect to an IP backbone. This connection between the WT and the backbone is ensured by bridging entities, which have the following tasks:

- Auto–Configuration (*e.g.* IP address configuration)
- Authentication of the WTs
- Accounting of the services used
- (QoS) for further research

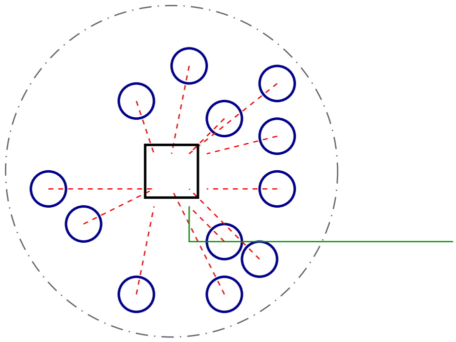

Figure 1: Wireless terminals are connected to the wired bridging access point via single–hop – AP/W/SH.

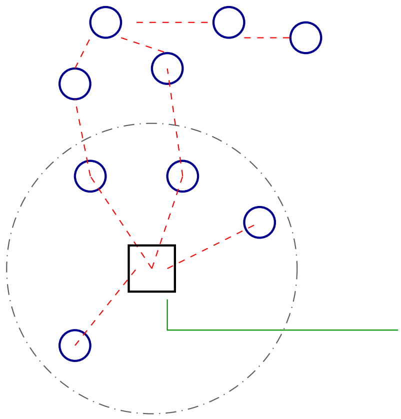

Figure 2: Wireless terminals are connected to the wired bridging access point via multi–hop – AP/W/MH.

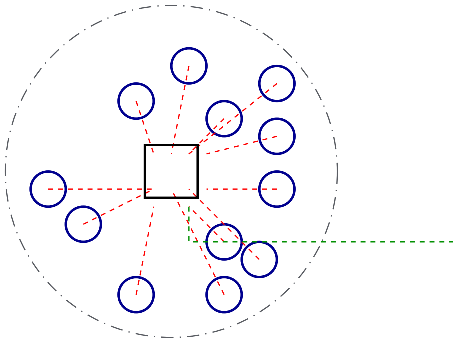

Figure 3: Wireless terminals are connected to the wireless bridging access point via single–hop – AP/WL/SH.

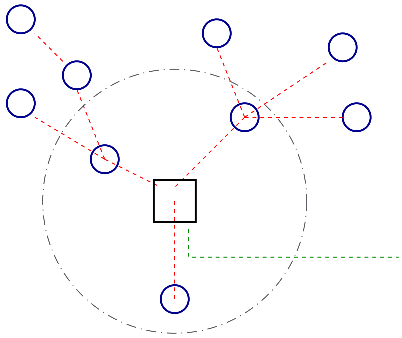

Figure 4: Wireless terminals are connected to the wireless bridging access point via multi–hop – AP/WL/MH.

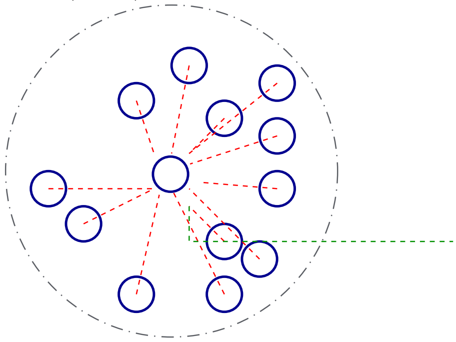

Figure 5: Wireless terminals are connected to the wireless bridging terminal via single–hop – T/WL/SH.

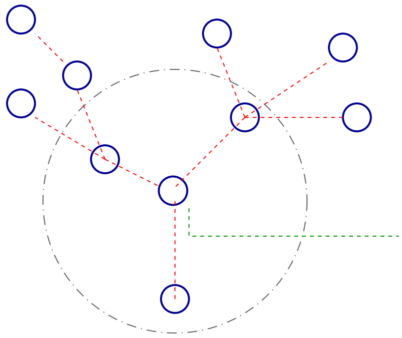

Figure 6: Wireless terminals are connected to the wireless bridging terminal via multi–hop – T/WL/MH.

Since we are only regarding the wireless case, the WTs can reach the bridging entity only over wireless links. The wireless link between the WT and the bridging entity can be single hop or multi–hop, depending on the scenario. The bridging entities can be classified by their mobility as either bridging terminals (mobile) or access points (fixed and part of the network). A terminal is always connecting to the IP backbone over another wireless link, while access points can connect either by wired or wireless links. A wireless terminal can only connect horizontally to the same technology, whereas bridging entities are additionally capable of connecting to another technology vertically. Since the communication in the vertical direction can be seen as subsequent following of the scenarios described in the following, we will leave them out in our description, but want to emphasize that these interconnections could be the cause of further problems encountered in the realization.

3 Terminology

Here and hereafter, we use the following terminology, derived from the means of connection:

type of bridging entity/vertical connection type/hopping mode

As characterized above, the bridging entities can be identified as either

- T – terminal bridge (mobile under the control of a consumer) *or*
- AP – access point (fixed under the control of the network).

The connection of the bridging entity to **its** backbone is either

- W – wired (AP only) *or*
- WL – wireless (AP and T).

Finally, the connection between the WT and the bridging entity can be done by either

- SH – single hop *or*
- MH – multihop.

4 Cases

Following we present cases that result from the different combinations of these bridging entities and the single or multi hop connection to the WTs. In addition to a short description, we present a sample application in form of a business case for each setup.

4.1 AP/W/SH

Here a fixed wired access point has been installed by a provider. WTs can join only inside the covered range of the wired access point forming a single cell. The coverage of larger buildings or areas has to be done by installing multiple wired access points.

Business Case: Airport

One example for this approach would be the wireless network at an airport, where providers would be able to install or access the wired network. In order to achieve a maximum coverage of the airport, a considerable amount of wired access points would have to be installed. An additional result is the control of the hand–over between the access points.

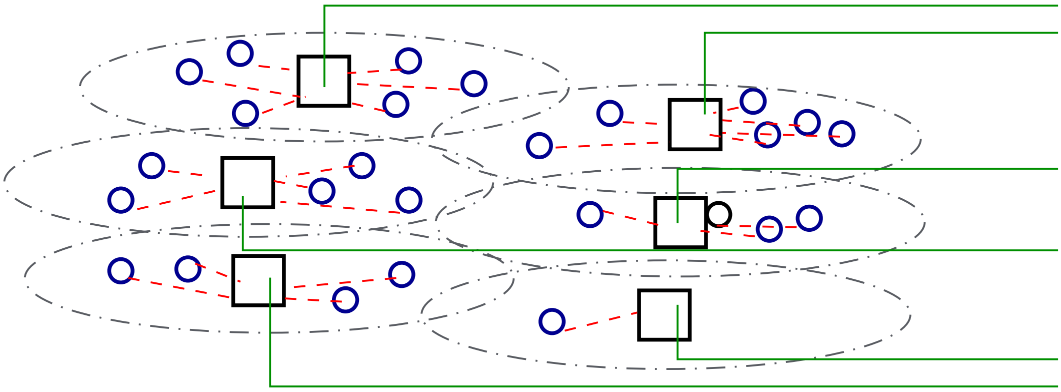

Figure 7: Multi cells as in airport business case

4.2 AP/W/MH

For this scenario, a deployment of a wired access point at a single location is extended by allowing multi–hop connection to the access point. This allows WTs that are outside the coverage of the fixed access point to gain access to the IP backbone via WTs that are inside the connection radius.

Business Case: Gas station

One possibility for the usage of this setup could be a gas station that provides connectivity to its customers. By installing one wired access point at the station itself that connects to the IP backbone, the multi–hop approach allows for coverage of the whole parking area.

4.3 AP/WL/SH

Here an access point that connects vertically by a wireless link is installed at a fixed position by the provider. The WTs can connect to the backbone only by direct communication with the bridging entity. Thus the restraint on this scenario is the covered range of the access point. The access point itself is connected vertically by another wireless link.

Business Case 1: Train

Consider a wireless access point within each wagon horizontally interconnected with the ones in the adjacent wagons, with the vertical communication links in the leading and trailing wagons. Each intermediate wagon would be supplied by its own wireless access point, with the two 'up–link' access points providing the connectivity to the IP backbone. By placing the up–links in the leading and trailing wagons, even in most tunnels the train would encounter by switching between both, the connection to the backbone could be held.

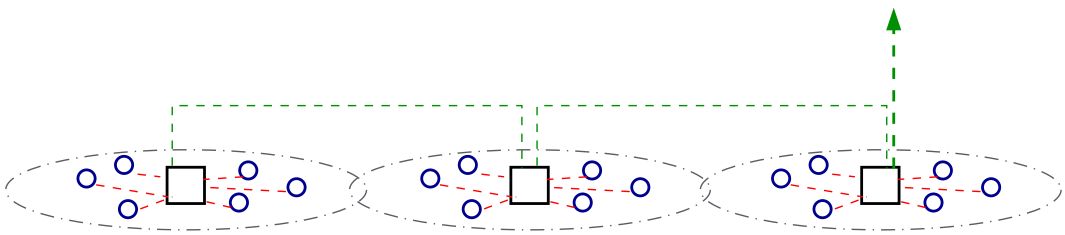

Figure 8: Serial alignment of cells as in train business case

Business Case 2: eHome

Consider a building with several rooms. Each wireless terminal (*e.g.* domestic environments) in a room is supported by an access point. The access points again are connected wireless with each other forming the the overlay network. One of the access points acts like a bridging entity to the next higher overlay network (*e.g.* UMTS).

4.4 AP/WL/MH

Here a wireless access point is installed at a fixed but remote site, so wiring is not favorable. The WTs are connecting to the access point either directly or by multiple hops in order to increase the possible coverage by the access point.

Business Case 1: Firefighters

Since the setup of a wireless access point has to be done preliminarily to any communication, this scenario could be applied to longer stays at the same site. The lack of wiring means that the setup is favorable to really remote sites or for the connection of larger groups of WTs that need connectivity. Considering the possibility of the enlargement of the covered radius around the wireless access point, especially in the firefighting scenario this ensures that the firefighters remain connected, even if the operating area is changed.

Business Case2: Body Networks

Many wireless nodes could by spreaded over the body. One of the nodes acts like the bridging terminal to the next higher overlay network. Nodes that could not reach the bridging terminal are using other nodes for multi–hopping.

4.5 T/WL/SH

In this scenario, the connection of the WTs to the backbone is realized by a bridging terminal. All WTs have to be inside the covered zone of the bridging terminal, forming a cell around it.

Business Case: Mobile Conferencing

When different people get together and want to keep their conference private, they certainly want to ensure that the coverage of their cell is determined by the initiator of the conference (assumed here as the bridging terminal).

4.6 T/WL/MH

In order to achieve a larger zone that is covered by the bridging terminal, WTs inside the covered radius are routing messages for those outside in an ad–hoc (multi–hopping) network. Only WTs inside the covered zone are using single hops.

Business Case: Mobile Gaming

Several players come together and want as many players as possible in their gaming session. In this case the network coverage has to be as large as possible, so a multihop approach should be favorable to get more players to join (see [1]).

5 Open Problems

Connection of the bridging entities does not happen to the backbone but to another technology's (wireless) network. This results in more configuration problems that have to be considered in future works. Additionally, as in the 'train' case, the connection and load balancing between the wireless access points could become an issue, especially if the next layer of technology used for the vertical communication has bandwidth limitations as well.

6 Future Work

The proof of concept for some of the reference models are planed by means of demonstrators. Problems like auto–configuration, authentication will solved and implemented in the demonstrator.

References

[1] Frank H.P. Fitzek, Gerrit Schulte, and Martin Reisslein. System Architecture for Billing of Multi-Player Games in a Wireless Environment using GSM/UMTS and WLAN Services. In *In Proceedings of the First Workshop on Network and System Support for Games (NetGames 2002*, NetGames2002, pages 58–64, April 2002. Braunschweig, Germany.