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Re:	802.16 Mobile SG Call for Contributions
Abstract	The document discusses the 802.16 OFDM PHY & MAC suitability as base-line for mobile applications
Purpose	To demonstrate that 802.16 can be base-line for a 802.16 mobile wireless standard
Notice	
Release	

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802.16 as base-line for a Wireless Mobile IP standard

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Introduction

This paper comes to demonstrate, with vehicular speed measurements, the suitability of the 802.16 OFDM PHY and 802.16 MAC as base-line for a standard addressing wireless mobile systems. Further improvement can be done with some modifications to the existing standard, and possible directions are shown in the document. A short overview of the IETF work for IP mobility is done, and common work directions with 802.11 are considered.
Considerations are made regarding the necessity of a single mobility PAR.

OFDM mobility experiment

Experiment set-up

The Alvarion's commercially available Breeze ACCESS OFDM system, operating at 3.5GHz, with 3.5MHz channel spacing, was used for measurements. The Base Station (BS) and Subscriber Station transmitted power was 20dBm. The BS antennae were installed at 25m above ground. The BS 120deg. antenna gain was 14dBi.
A Subscriber Unit (Station) was mounted in a car. The mobile unit used an external omni antenna, 7dBi gain.
The system uses a fast ACK mechanism.
The Base Station was mounted on a roof, having radio visibility to a HWY (Highway) zone, in the east, and to an urban zone, in the west.
The terrain was flat, in the HWY (east) direction; a small hill is located at west, in the urban area direction.
The cellular deployment simulations correspond with the power levels measured on field. The RSSI colors correspond to product data sheet values, for different PHY rates.

Highway measurements

The east area topographic map is shown in figure 1. Between the Base Station and HWY there are fields and tree plantations.
The simulation prediction of the RL (Received Power Level) on HWY is shown in fig. 2, inside the area marked with magenta line.
The measurements were done at PHY rates of 8Mb/s and 12Mb/s. The RL was measured for every packet, for different travel speeds, on a 2km driving distance, along the HWY. The data rate, in FTP Get and FTP Put, for both Subscriber Unit and Base Station, was function only of the received RL, and independent of vehicle speed.
The experiment performed repeatedly with constant or variable car speeds ranging from 40km/h up to 120km/h.
The connectivity was achieved at distances of up to 1.5km from the Base Station.

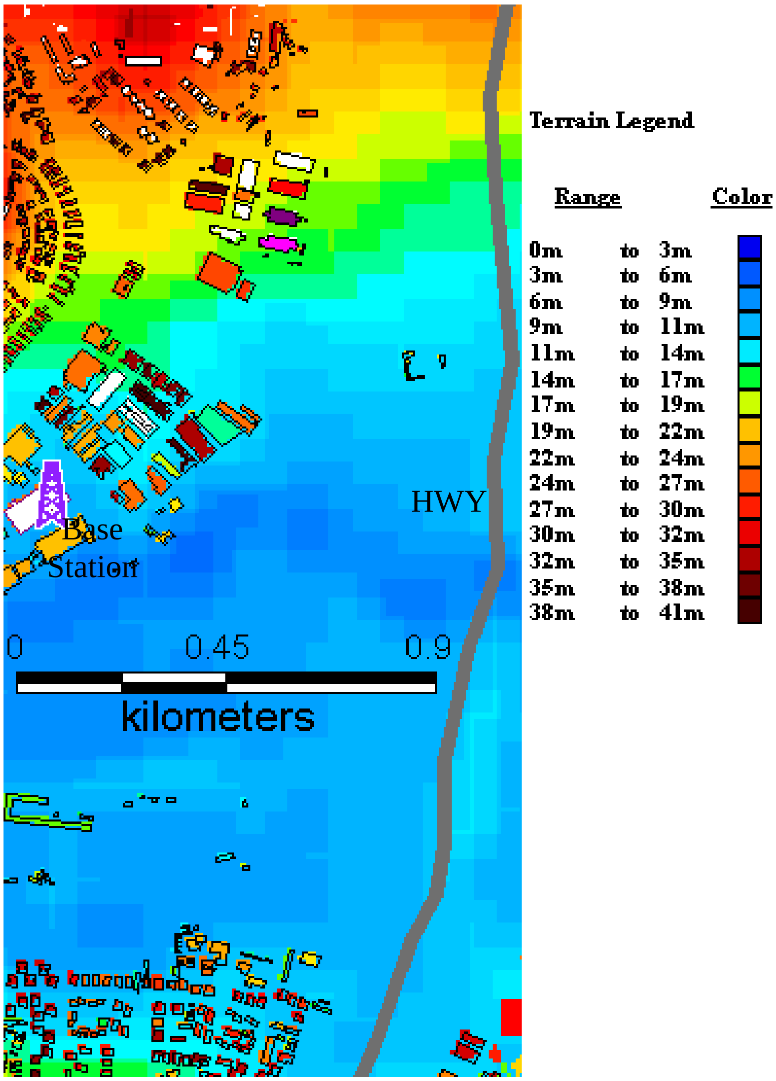

Fig.1 – Topographic map of the HWY measurements

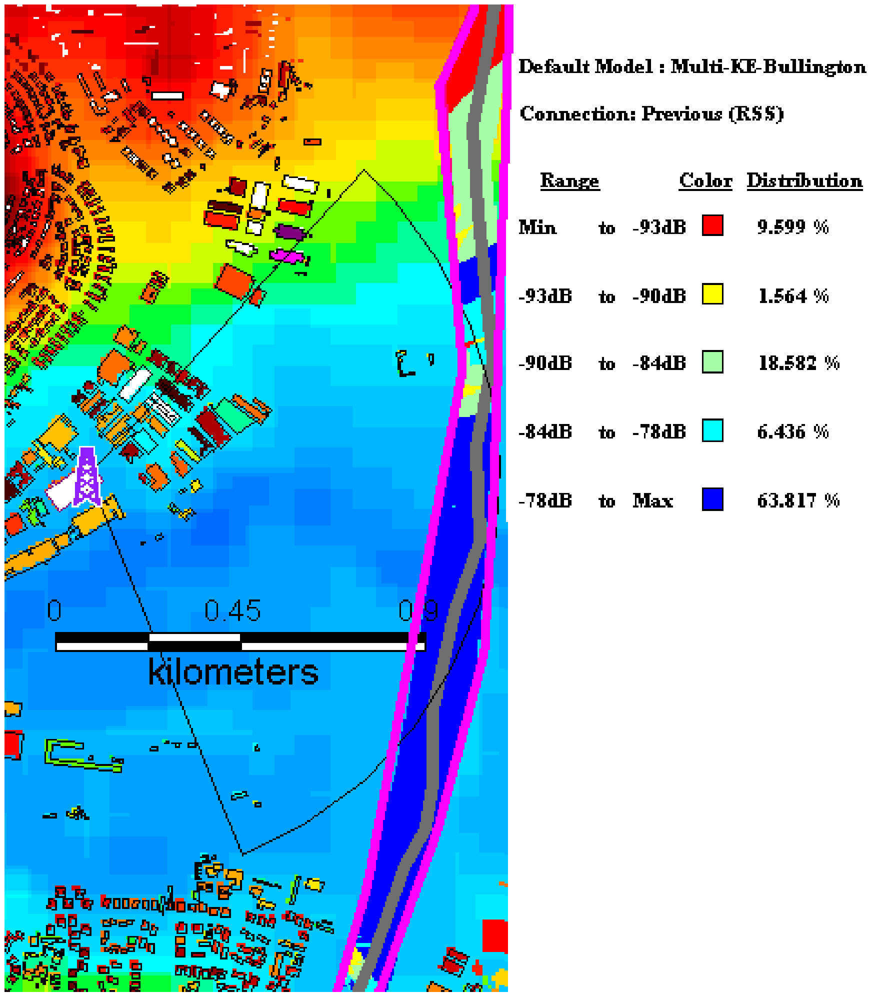

Fig. 2 – HWY RL simulation

Urban measurements

Fig. 3 shows the urban area aerial photography, and fig. 4 shows the topographic map of the urban area.
West to BS, the small hill, has approximately same height as BS antennae, and with trees on top.
The RL according to the cellular deployment simulation is shown in fig.5, in the magenta circled area.
The 120deg. BS antenna coverage is included.
The system has worked in ALL the magenta circled area, including the top-of-hill trees, up to 60km/h (maximum urban speed limitation), in spite the simulation that predicted connectivity in only 57% of the area.
Red inside the magenta marked zone indicates that there is not enough level for coverage. The maximum

connectivity radius was 1km. Same throughput has been obtained in static and moving situations, being observed no dependence of the PHY rate versus the moving speed.
The PHY rate, function of the receive power level, varied between 12Mb/s and 2Mb/s.

Fig.3 Measurement site - photo

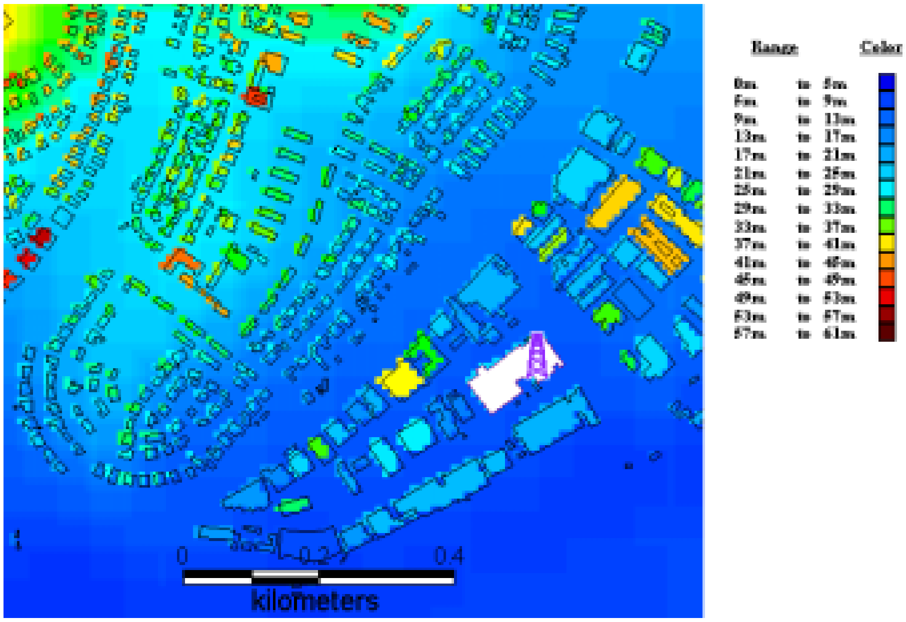

Fig. 4 – Urban measurements – topographic map

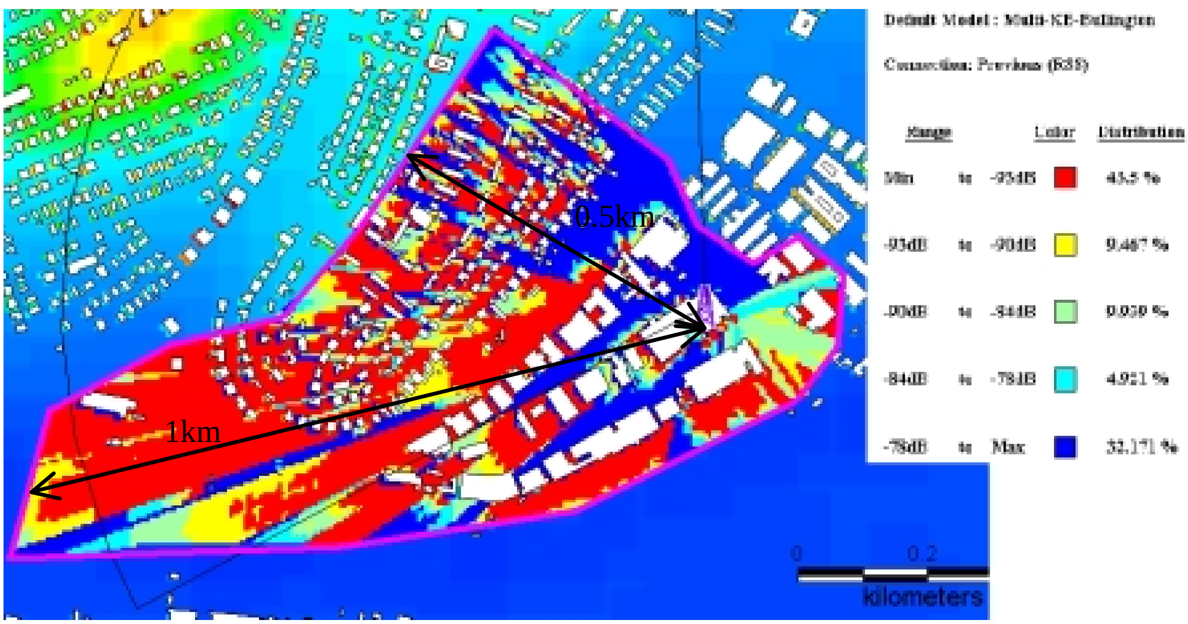

Fig. 5 – RSL prediction

Conclusions from the experiment

Our conclusion from the set of experiments we've performed with a representative OFDM system is that 802.16a system with OFDM PHY is a good baseline for a MBWA system. The performance was dominated by the received signal level, rather than by multipath distortion.

Adaptation of the 802.16a OFDM to MBWA

802.16a OFDM PHY adaptations

The field measurements have shown good OFDM system behavior in mobile environment, from vehicular speed p.o.v. as well as from connectivity p.o.v. in NLOS conditions. The main directions for further improvement that may be taken into consideration are:

- Fast channel learning – insertion of mid-ambles at variable symbol intervals, depending of mobile unit speed and OFDM symbol duration;
- Sub-channelization in up-link, to allow power saving and link budget improvement for mobile terminals;
- Support for fast ACK mechanism, using a sub-carrier based mechanism; sub-carrier based mechanism is already used for focused contention;
- Support for fast power control and ranging, fast rate adaptation, using a sub-carrier based mechanism.

802.16 MAC adaptations

The existing 802.16 MAC is well designed for QoS support, required by multi-media applications.
The main topics for mobility support will be:

- Hand-off, inclusive IP context;
- Power saving
- Fast ACK mechanism

The 802.11 group has invested a lot of work in this area, like the 802.11f (Inter-AP Protocol), and an effort should be made to understand and eventually re-utilize the valuable parts of the 802.11f standard.

IP mobility

There are at least four IETF directions [3], regarding the mobile IP issue: Mobile IP, Cellular IP, HAWAI and TIMIP protocols. The differences between protocols are related to the need of 1 or 2 addresses and new IP stacks for mobile units, the routing complexity, etc. Some of the protocols try to use Mobile IP for macro-regions and fast (short) routing inside local zones.

The Alvarion perception is that in the selection of a suitable IP mobile protocol, the Hot Spot market will have a considerable influence, and 802.16 should use the WLAN experience to provide a full solution for mobile applications.

Conclusion

This paper shows that 802.16 with the OFDM PHY can be a good base-line for mobile applications. It provides high data rates (almost 4bit/s/Hz), works in NLOS and fast ARQ can be implemented, responding to requirements in [1], [2].
We demonstrated, through field measurements, that 120km/hour at >3bit/s/Hz is already reality. Regarding the 250km/h, that can be useful for roof-train applications, used as feeding of the inside-train Hot-Spot, it may require a separate PHY profile. Nevertheless, we consider that is no justification for two different 802 Mobility Working Groups, and we fully agree with the conclusions of [2]. 802.16 is able to bring the achievements of almost 3 years of work on both MAC and PHY, and improve them to optimally support mobile terminals up to 120km/h. The natural location of the 802 Mobile activities should be inside 802.16.

Bibliography

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