ODMA
Opportunity Driven Multiple Access

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Opportunity Driven Multiple Access is a mechanism for maximizing the potential for effective communication. This is achieved by distributing intelligence within communicating nodes and providing multiple communication paths between them. The intelligent nodes measure and evaluate their communications options and adapt to exploit the optimum opportunity.

1.0 Introduction

Mobile telecommunications has reached a critical point in it's evolution. Existing frequency allocations are becoming congested yet there are predictions that 60% of the population will one day own mobile telephones.
Coupled to this is the explosion in multi-media services supported on IP networks, which will raise user expectations of communication and increase demands for bandwidth.

How will future mobile systems cope with the orders of magnitude increases in both the number of subscribers and traffic?

If for a given data throughput the transmitted power of a mobile is significantly reduced then there is a potential solution to the capacity problem, but this implies an improvement in the signal to noise ratio. The ratio is affected by a wide range of parameters including radio frequency and path. Fixing these parameters immediately prior to transmission may be considered as equivalent to selecting an operating point along a multi-dimensional vector.

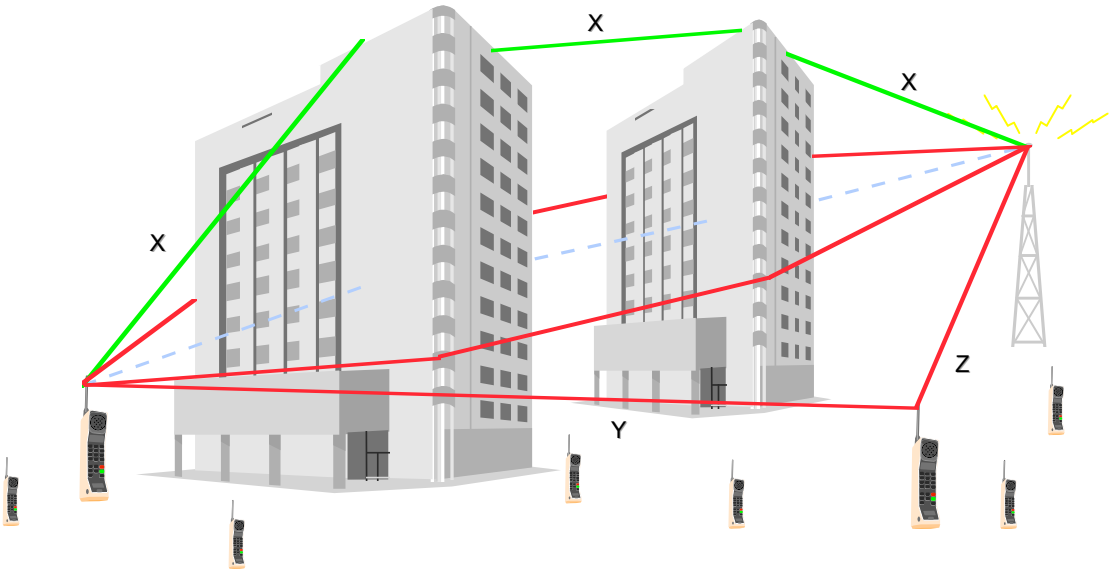
ODMA is a means of choosing an optimum point along the vector where the signal to noise ratio is at a maximum.

For it to work effectively there must be many dimensions (things to adapt) and each dimension should have a wide dynamic range. There must also be a precise real time measurement system and intelligent dynamic control.

2.0 Adaption Space

ODMA requires the adaption of many parameters to optimize communications, but one of the most powerful is path diversity. This is exploited by ODMA mobiles acting as repeaters so that a call reaches it's destination via a number of hops.

Fig 1 Benefits of Path Diversity



It can appreciated from Fig 1 that the signal loss can vary tremendously based on the choice of path. Consider that path X represents a mobile to base station route. By choosing instead to hop through the LOS paths Y & Z one could easily imagine a 30dB loss reduction i.e. for the same data throughput the total TX power at each hop could be reduced by a factor of 1000 e.g. 1mW instead of 1W.
The extent of the gain will be highly variable both with time and frequency but will be related to the number of paths available, which will increase with greater local subscriber density.

A GSM mobile could be considered as a very constricted ODMA system i.e.;

* The phone has only one route to a base station (but may have a choice)
* It operates on a fixed allocated frequency pair (unless hopping)
* It must transmit in an allocated time-slot regardless of interference.
* It must transmit with a fixed data rate and packet size regardless of BER.
* Its power output control has limited dynamic range.

Furthermore division and allocation of air-interface connection resources per call limit the opportunities for other phones to communicate and reduce potential efficiency.

An ODMA mobile breaks through these limitations by communicating via it's neighbors using intelligent subscriber relay.

> ***A fundamental of the ODMA philosophy is that communications is considered as a dynamic localized activity best controlled at node level rather than from some centralized intelligence***

3.0 The Fundamentals of an ODMA mobile.

An ODMA mobile is effectively an intelligent burst mode radio which has the potential for using all of the available bandwidth for some of the time. Depending on instantaneous conditions a mobile can transmit at data rates from 8kbits/s to 8 Mbits/s.
As distinct from existing Cellular systems, all mobiles operate in the same wide frequency band but automatic frequency hopping at lower data rates dynamically introduces sub-bands. The choice of modulation scheme is not critical to the ODMA concept but experiments to-date have followed the GSM example and used GMSK.
Transmission is completely packet based and connectionless and each mobile is able to relay packets from its neighbors; furthermore, a mobile will adapt its transmission route on a packet by packet basis, as well as power, data rate, packet length, frequency, time window and voice quality over a wide dynamic range.

Each mobile has responsibility and (to a large degree) autonomy for local routing and optimal adaption to the communication environment, although it will accept the authority of a network supervisor.

> ***The nodes collectively share responsibility for maximizing Erlangs/km^2/Hz which poses the greatest technical challenge and key to the whole approach.***

4.0 ODMA - The Human Communication Analogy

The principles of ODMA are founded on observations of human behavior in different scenarios. Consider the scenario when pairs or small groups of people wish to communicate but find themselves part of a larger gathering

3.1 The GSM Meeting

Consider the case of meeting to discuss GSM principles. In the room there would be communications experts and a Chairman. Questions would be through-the-chair with individuals raising their hands and waiting to be allocated an opportunity to speak to another expert. The Chairman would speak loudly so that every one could always hear him and the selected pair of experts would be allowed to do the same.

The proceedings would be very disciplined and predictable and fine if everyone was interested in the same conversation but there would be limited opportunities to exchange more private information even between near neighbors.

3.2 The ODMA meeting

At an ODMA meeting, you would have a similar group of communications experts but the Chairman would not be required due to the attendees' strict code of conduct. On arrival each delegate would make polite introductions so that after a while everyone would know their neighbors and have a reasonable idea of who else was in the room. Some experts would be in groups sitting close enough together to chat softly which would generate a background noise level adding to the drone of computers, air conditioning etc. Others would have to communicate longer distances, in a manner which would be effective above the background noise yet would not disturb the group conversations.

Example;

A delegate in an ODMA meeting wishes to speak to a particular expert who is rumored to be on the far side of the room but the behavioral rules prevent him from shouting. The delegate then asks a neighbor to pass on a short question to the expert and the answer duly returns. The delegate then has a much longer question but knowing that he is not allowed to speak continuously, communicates the question to his neighbor with pauses between short sentences and again his answer returns. The delegate has another question but this time his favorite neighbor is busy, and his secondary choices have difficulty hearing. The delegate compensates by either speaking slowly and softly with short sentences or rapidly and slightly louder with perhaps longer sentences. Occasionally the background noise is reduced and the delegate can speak rapidly yet softly.

Towards the end of the meeting many of the attendees have left leaving a sparse population of delegates. Those remaining attendees may need to talk louder to communicate which is permissible as there are fewer conversations to interfere with.

> ***By using principles of human communication, ODMA has the potential to have more subscribers engaged in more conversations and using more bandwidth than GSM.***

5.0 ODMA as a Solution to UMTS Requirements.

UMTS has recognized the convergence of IT and Telecommunications as an inevitable necessity to augment traditional telephony with diverse multi-media services for the mobile subscriber - rather like a mobile intranet. This necessitates a variable user-rate, bandwidth-on-demand asymmetric system probably using a packet approach in the air interface as well as the infrastructure. It is also emerging that a multiple access

scheme is required that supports communications via uncoordinated base stations such as cordless or cellular.

An ODMA mobile fits easily within these requirements and it can automatically adjust from being a high bandwidth short-range cordless connection to a medium bandwidth mobile link. It also has exceptionally low roll-out costs starting with good coverage but low capacity from relatively simple base stations. The capacity must scale up as the number of subscribers increases but to some extent this is automatic as each new mobile adds to the network infrastructure.

It is quite possible that regulators will no longer divide frequency bands amongst network operators but rather provide multiple licenses for the whole band, placing the onus on the operators to devise a cooperative scheme for bandwidth sharing - sometimes called *mixed-bathing.*

ODMA has potential to offer a bandwidth sharing solution, as the mobiles are all *mixed-bathing* in *a* common frequency band and can carry each others packets if desired.

ODMA satisfies the criteria for UMTS.

6.0 Evolution

ODMA is a radically different philosophy to GSM yet some of the basic functionality has similarities e.g. modulation, measurement, power control, processing etc. This suggests that it would be possible to produce a dual GSM-ODMA mobile which would provide a suitable evolutionary path from Second to Third Generation systems.
However it also begs the question that with access to the synchronization knowledge from the GSM sub-system, could ODMA be overlaid on the same GSM frequencies with minimal interference ? In fact, could ODMA be overlaid on any band (such as TACS) to scavenge unused capacity ?

7.0 Air Interface Standards

It is vitally important to the success of future mobile communications that the best air interface is selected and performance testing of the air interfaces is the ultimate acid test. Evaluation tests should measure the effectiveness of the solution to the outlined problems e.g. capacity/ bandwidth etc. and not suggest the methods used to achieve that solution.

ODMA as a subscriber relay system fits reasonably well within the wording of evaluation documents derived from conventional cellular systems but the following definition may help clarification;

ODMA Cell

An area containing ODMA Base Station Infrastructure to support a number of subscribers. The ODMA Base Station Infrastructure consists of a base station provided for capacity plus zero or more relays to ensure acceptable coverage.

8.0 Summary

Opportunity Driven Multiple Access (ODMA) is a strong potential candidate for the third generation air-interface.

The ODMA philosophy embraces the concept that communications is a localized activity best handled by intelligent adaptive mobiles.

A vital ingredient of ODMA is path diversity in the form of subscriber relay which can result in significant reductions in transmitted power.

ODMA maps closely onto UMTS requirements and provides an opportunity for use of the same spectrum by different operators.