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Agenda Item: 11

Source: Philips

Title: The FAUSCH Concept

Document for: Discussion and Decision

Summary:

This paper (an earlier version of which was previously circulated for discussion by email) briefly describes the main technical features of the FAUSCH (Fast Uplink Signalling Channel). It also outlines the history of the previous discussion in ETSI. One of the ETSI documents on packet data applications is included as an annex. Originally considered to be applicable to both FDD and TDD modes, the FAUSCH concept has so far only been fully developed for FDD mode.

The FAUSCH concept is described in ETSI document XX.03 and already included in the merged text as part of various 3GPP Layer 2 documents (e.g. S2.03, S.2.21). It is currently under consideration for inclusion in S1.11: Transport and physical channels (FDD).

Due to its performance benefits for uplink packet transmission and low additional implementation complexity it is proposed that FAUSCH be retained in the 3GPP specification.

1. INTRODUCTION

The FAUSCH (Fast Uplink Signalling Channel) proposal was motivated by the recognition that:

- The RACH channel has an inherent risk of collision
- When only a small message is to be conveyed, the overhead associated with the use of the RACH is significant.

The FAUSCH channel offers a collision free signalling channel with low overhead. Although various possibilities have been discussed, the most beneficial application appears to be for the uplink (reverse link) transmission of small or medium sized packets (up to a few hundred bits). In this case the use of FAUSCH can give significant advantages in terms of Eb/No, leading to higher system capacity. The fact that FAUSCH is collision free gives improved reliability and reduced transmission delay, particularly with high system loading.

Mobile terminals wishing to make use of FAUSCH are allocated a dedicated access slot. Transmission of a cell-specific code sequence in this access slot is used to convey a 1 bit signalling message. The meaning of this 1 bit would need to be established in advance. In the envisaged packet transmission application, the signalling message is a request for the use of a dedicated channel (DCH) in the uplink direction. The uplink resource would be granted on the forward access channel (FACH), and the packet transmission would then begin using the DCH. The procedure would be similar if a DCH is reactivated after a break in transmission. The Eb/No (including overheads) is found to be lower using FAUSCH in this way than using RACH ["Proposal for Unified RACH and FAUSCH", Tdoc SMG2 UMTS L1 7/99, Philips]. This is the case whether the RACH channel is used to set up a DCH or whether the user data is sent as part of RACH packet. The Eb/No improvement is most significant where a large number of packets are to be sent, but where the average bit rate and transmission duty cycle are low enough that continuous use of a DCH would be inefficient.

Therefore FAUSCH is beneficial for uplink packet transmission in those cases where a continuous DCH is not appropriate. Such applications are discussed in ["Some applications requiring uplink packet transmission", Tdoc SMG2 UMTS L1 8/99, Philips.], and in total could generate a significant fraction of the total system traffic. It should further be noted that FAUSCH can be an optional feature since equipment using it can coexist with equipment which does not.

2. IMPLEMENTATION DETAILS

The code sequence now used for FAUSCH is identical to that used for the RACH preamble (ETSI proposal). A 256 chip Gold code is used to spread a 16 bit signature, exactly as in the RACH preamble. As mentioned above, a mobile terminal would be allocated a fast access slot with a specific timing offset in the 10ms frame relative to the downlink synchronization channel (SCH). Although the time slots are distinct, the transmissions from different terminals would typically overlap at the receiver in the network. However, the receiver can identify which mobiles have signalled by detecting separate peaks in the output of a correlator or filter (matched to the spread signature).

The minimum useable separation between fast access slots will depend to some extent on the deployment scenario. The limiting factors will be delay spread and round trip propagation time. This means that in large cells the spacing between fast access slots should be increased. This is accommodated by defining a minimum spacing (16 chips). In small cells all the fast access slots could be allocated. In larger cells every N'th slot could be used.

Potential interference between RACH pre-ambles and FAUSCH transmissions is avoided by allocating different parts of the frame to RACH and FAUSCH. This could be achieved by splitting the frame into two parts, or interleaving the allocations [see 1]. This is fully consistent with the option to restrict the use of RACH to a subset of the possible PRACH access slots. In any case the availability of slots for RACH will be indicated on BCH.

Due to the high degree of commonality in implementation details this FAUSCH concept has been incorporated within the ETSI PRACH (physical channel supporting RACH). Here, a single signature is used for the FAUSCH. The selected signature is number 8, since this has the best auto-correlation properties. This allows the same receiver hardware to be used for RACH and FAUSCH, and minimal additional complexity is required to support both.

If more RACH and/or FAUSCH capacity is needed, then additional Gold codes could be used to provide additional PRACH channels. These could be allocated to RACH and/or FAUSCH as appropriate for the prevailing traffic conditions.

Since FAUSCH offers collision free operation and better Eb/No than RACH for packet transmission, the overall system performance will typically be improved if the PRACH resource is split between RACH and FAUSCH.

3. HISTORY

This section summarizes the development of the FAUSCH concept (mainly in ETSI SMG2 UMTS L1 and L23 expert groups). The key documents mentioned are listed in the annex.

The need for fast uplink signalling was noted in April 98 in Tdoc UMTS L23 27/98, and the limitations in RACH performance noted in June 98 in Tdoc UMTS L23 104/98. The FAUSCH concept was first introduced by Philips in the Layer 1 Expert Group in July 98 in Tdoc UMTS L1 227/98 and in the Layer2/3 Expert Group in September 98 in Tdocs UMTS L1 162/98 and 182/98. Since the FAUSCH concept required changes in both Layer 1 and higher layers, the idea was also presented at an SMG2 UMTS ad-hoc meeting (Tdocs UMTS 119/98 and 165/98).

In the L1 group a large number of questions were raised and clarifications requested and answers were given in Tdocs UMTS L1 330/98 and 463/98. Tdoc UMTS L1 329/98 gave some indication of the detection performance achievable with code sequences of the type then proposed for both RACH and FAUSCH.

Although the L1 group had not yet adopted FAUSCH, it appears that a misunderstanding occurred in L23 group, to the effect that FAUSCH was already a working assumption. This was one of the issues raised in the Liaison statement from L23 to L1 group (Tdoc UMTS L1 486/98). However, the L1 group indicated in Tdoc UMTS L1 501/98, that although the concept was not a working assumption, this status might change. This seems to have been a sufficiently positive statement for FAUSCH have been retained and subsequently further developed in the L23 documentation (e.g. first in YY.02 and then in YY.03, YY.21, YY.31 etc).

Further performance results were presented to L1 group in Tdoc UMTS L1 530/98. In a Liaison statement to L23 group (Tdoc UMTS L1 597/98), L1 group indicated that the FAUSCH was now recognised as a good candidate for sending long packets and could supplement the RACH in that application (but still not yet a working assumption). Performance results for packet transmission were also presented to L23 group (Tdoc UMTS L23 399/98).

Tdoc UMTS L23 480/98 describes when and how to use FAUSCH, and Tdoc UMTS L23 481/98 emphasizes the performance limits of the RACH.

At the L1 group meeting in December 98 the paper Tdoc UMTS L1 623/98 gave results in terms of Eb/No for packet transmission, and showed the advantage of FAUSCH compared with RACH. The paper Tdoc UMTS L1 626/98 showed how the code sequence required for FAUSCH could be implemented in a simple way. At the same meeting Ericsson proposed a unified concept for RACH and FAUSCH (Tdoc UMTS L1 671/98). However, some concerns were expressed on whether likely applications for UMTS justified the use of FAUSCH, and on implementation complexity (Tdoc UMTS L1 675/98). A liaison statement to L23 group (Tdoc UMTS L1 761/98) mentioned these concerns, but indicated that the FAUSCH concept had been retained for further study and possible merging with RACH.

In the next L1 meeting in January 99, the paper Tdoc UMTS L1 7/99 proposed a unified RACH and FAUSCH, both supported by the PRACH (Physical RACH). Complexity figures were also given showing that no new hardware would be needed for FAUSCH, and any increase in complexity would be of minor significance. Tdoc UMTS L1 8/99, describing applications which would benefit from the use of FAUSCH, was provided for that meeting, but not formally presented due to lack of time. However, there were no further objections to a FAUSCH and the relevant text was drafted and approved for inclusion in XX.03 (UTRA FDD Transport channels and physical channels).

Meanwhile in Layer 23 group, the use of the FAUSCH concept was further developed, and the relevant text from ETSI adopted by RAN TSG WG2 in the merged 3GPP documents relating to Layer 2 (although still conditional on FAUSCH being adopted at Layer 1).

4. CONCLUSION

It will be apparent that since the FAUSCH concept was originally proposed it has been refined and improved in response to comments and discussion. The final result offers useful performance improvement at the cost of very little additional complexity. Therefore it should be retained as part of the 3GPP specifications.

REFERENCES

1. "Proposal for Unified RACH and FAUSCH", Tdoc SMG2 UMTS L1 7/99, Philips

2. "Some applications requiring uplink packet transmission", Tdoc SMG2 UMTS L1 8/99, Philips.

Annex 1: Relevant Papers

The key papers are listed here, which are enough to cover the main technical issues and history of the discussions. The dates given are those of the meetings for which the papers were prepared, and are not necessarily the same as the date of distribution by email or discussion.

Table 1. List of ETSI SMG2 UMTS L1 Expert Group papers covering FAUSCH.

Title	Source	Date	Document #
Fast uplink signalling mechanism for FDD and TDD systems	Philips	15/7/98	227/98
Uplink Signalling Performance	Philips	8/9/98	329/98
Fast Uplink Signalling – Questions Answered	Philips	8/9/98	330/98
Fast Uplink Signalling – More Questions Answered	Philips	14/10/98	463/98
Liaison Statement to the L1 experts group	L23 Experts Group	14/10/98	486/98
Answer to Liaison Statement	L1 Experts Group	14/10/98	501/98
Comparison of RACH and FAUSCH physical layer performance	Philips	9/11/98	530/98
Liaison statement to L2/3 Group	L1 Experts Group	9/11/98	597/98
Comparison of Eb/No for packet transmission using RACH and FAUSCH	Philips	14/12/98	623/98
Simplified FAUSCH realisation using concatenated codes	Philips	14/12/98	626/98
A unified concept for random access and fast uplink signalling	Ericsson	14/12/98	671/98
Use of FAUSCH channel in UTRA	Nokia	14/12/98	675/98
Liaison statement to Layer 2/3	L1 Experts Group	14/12/98	761/98
Further results on RACH and FAUSCH physical layer performance	Philips	18/1/99	1/99
Proposal for unified RACH and FAUSCH	Philips	18/1/99	7/99
Some applications requiring uplink packet transmission	Philips	18/1/99	8/99

Table 2. List of ETSI SMG2 UMTS Layer2/3 Expert Group papers covering FAUSCH

Title	Source	Date	Document #
Requirement for fast uplink signalling in UMTS	Philips	27/4/98	27/98
Performance results for the RACH	Philips	23/6/98	104/98
Fast Uplink Signalling Mechanism for FDD and TDD	Philips	1/9/98	162/98
Performance comparison of RACH and FAUSCH for rare signalling events	Philips	1/9/98	182/98
YY.02 v 0.4.0 Layer 1: General Requirements	L23 Experts Group	Oct 98	-
RACH performance for 64kbps user streams	Philips	12/11/98	399/98
When and how to use the FAUSCH	Philips	9/12/98	480/98
Error floor of RACH missed detection	Philips	9/12/98	481/98
CR to YY.03 to incorporate the FAUSCH for URA connected states	Philips	9/12/98	521/98
CR to YY.21 and YY.31 to include FAUSCH specific details	Philips	18/1/99	68/99

Table 3. List of ETSI SMG2 UMTS ad-hoc papers covering FAUSCH.

Title	Source	Date	Document #
Performance results for the RACH (rev1)	Philips	6/7/98	119/98
Uplink Signalling	Philips	6/7/98	165/98

Annex 2:

The following Annex contains the ETSI SMG2 UMTS L1 paper Tdoc 8/99 “Some Applications requiring uplink packet transmission.

ETSI SMG2 UMTS L1 Expert Group **Tdoc SMG2 UMTS-L1 008/99**
Meeting No. 10
Espoo, Finland
18-20th Jan 1999

Source: **Philips[1]**
Title: **Some applications requiring uplink packet transmission**
Date: **11th Jan 1999**

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1. INTRODUCTION

One of the major motivations for proposing a fast uplink signaling (FAUSCH) scheme for UMTS FDD mode, as in [“Proposal for unified RACH and FAUSCH”, Tdoc SMG2 UMTS L1 007/99, from Philips], is to improve the performance for packet transmission in the uplink. It has already been shown (e.g. in [“Comparison of Eb/No for packet transmission using RACH and FAUSCH”, Tdoc SMG2 UMTS L1 623/98, from Philips]) that using FAUSCH (to re-activate an uplink DCH) offers an improved Eb/No for small-to-medium sized packets, compared with the use of RACH. In addition, the RACH can suffer from contention problems at high loading. However, it has been suggested (e.g. in [“Use of FAUSCH channel in UTRA” , Tdoc SMG2 UMTS L1 675/98, from Nokia]) that the applications foreseen for UMTS do not justify the incorporation of FAUSCH. In order to refute this argument the current document explores potential applications, which could exploit FAUSCH. From this perspective the feature of interest is the generation of uplink packet traffic which does not imply significant associated downlink resource. This is because if the downlink traffic component were large, then the system capacity in the downlink would be the limiting factor. Then it could be argued that improving efficiency in the uplink is not beneficial. In addition, if a dedicated channel is established for downlink traffic, then the corresponding DCH in the uplink could be used for packet transmission.

Therefore we consider applications which depend on uplink packet transmission, and where the packet size and arrival rates are such that use of RACH or FAUSCH is likely to be more efficient than the continuous use of a dedicated channel.

2 APPLICATIONS

First we present applications proposed elsewhere. As well as symmetric packet traffic, we are interested in asymmetric traffic where the uplink dominates, or applications where the downlink channel is provided by another (broadband) system.

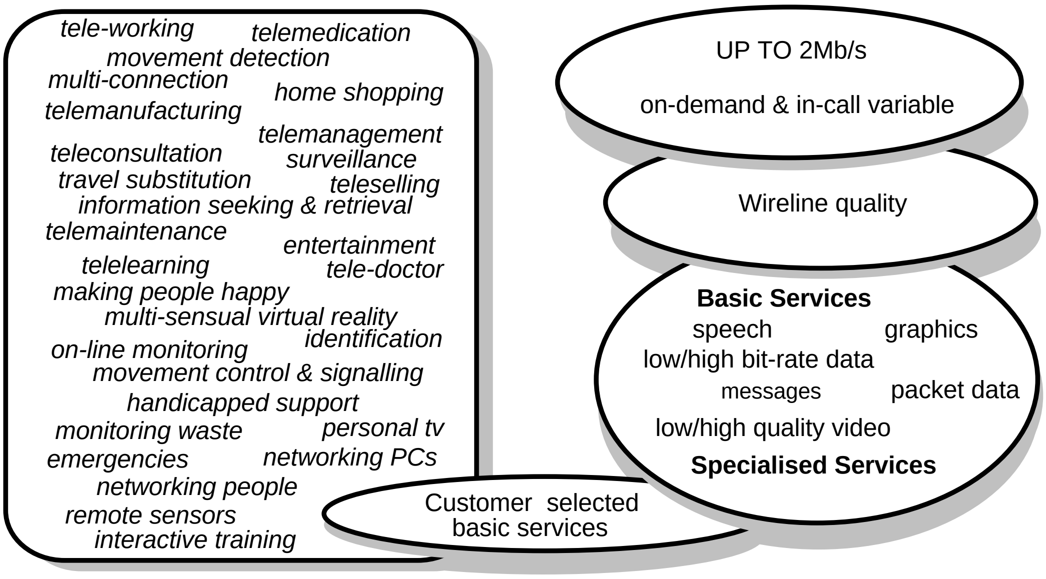

Figure 1 Customised Multi-media

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Figure 1 shows some applications already identified by the UMTS Task Force ["UMTS Task Force Report", UMTS Task Force, February 1996]. Of these we consider the following most relevant:

- Movement detection
- Telemanufacturing
- Surveillance
- Information seeking and retrieval
- Telemaintenance
- Entertainment
- On-line monitoring
- Movement control and signalling
- Monitoring waste
- Networking PCs
- Remote sensors

Some general indications of expected applications are given in ["Mobile Communications Move On", http://www.ericsson.com/Connexion/connexion2-93/rd.html], where it is stated that *"Some potential applications that UMTS will be expected to support are:* ***telemetry, credit card authorisation****, database access, messaging, E-mail, electronic document transmission, file transfer,* ***terminal emulation****, simultaneous voice and data, fax, live video, slow-scan TV, pre-recorded TV, and multimedia.* ***The concept must, however, be flexible enough to support data services that are not even possible to define today***."

The ACTS project CRABS ["Cellular Radio Access for Broadband Services", http://www.infowin.org/ACTS/RUS/PROJECTS/ac215.htm] considers video delivery (DVB) with an interactive return channel: *"These trials, which are in two phases, provide several channels of* ***digital broadcastin****g at 42-GHz with* ***an interactive return path*** *initially* ***at low data rates****. This utilises either existing radio-based systems (DECT or GSM), or twisted pairs."* The return channel could be provided by UMTS.

The ACTS project MEMO ["Multimedia Environment for Mobiles", http://www.infowin.org/ACTS/RUS/PROJECTS/ac054.htm] considers digital audio delivery with an interactive return channel. *"The main objective of MEMO is to develop a generic architecture for the provision of interactive multimedia services to mobile and portable terminals. The system will provide an asymmetrical bi-directional link combining a* ***broadband downlin****k (based on DAB) and* ***a low bitrate interactive link*** *(based on GSM). Two types of example services will be implemented:*

- *applications from electronic publishing (newspaper, videotext), based on the .htm format, with strong interactive functionalities.*
- *applications from the construction industries, featuring on-demand downloading of large amounts of data to user groups and collaborative work on the data."*

The integration of DAB in a PC, allowing applications combined with Internet access, is also proposed in [W H W Tuttlebee and D A Hawkins, "Consumer digital radio: from concept to reality", Electronics & Communication Engineering Journal, p263-276, December 1998]. Again, the return channel could be provided by UMTS.

At least one ESPRIT project ["IT for mobility", http://www.cordis.lu/esprit/src/itfmaprj.htm] considers telemetry in an industrial environment: "MOFDI will develop a common radio support to connect existing industrial devices into Fieldbus systems and allow improved site management using real time data from all locations such as: a) Mobile operator terminals and configurators needing access to Fieldbuses for plant information. b) Mobile and inaccessible field devices (such as instruments in rotating machines, cranes, site vehicles etc)". Such requirements could be met by UMTS.

There are several different mobile packet data services currently deployed, notably in North America, such as CDPD, Mobitex, DataTac and Metricom Richochet ["Packet Data", http://www.gsmdata.com/packet.htm]. Typical user bit rates are less than 16kbps. A typical application is transmission of brief messages to or from a PDA. UMTS could carry similar traffic.

In ["Added Value for GSM", http://w2.siemens.de/telcom/articles/e0298/298gsm.htm] a vending machine application (amongst others) is described: *"At Finland's Helsinki airport customers can even* ***pay*** *to quench their thirst from a soft-drink machine by mobile telephone* ***without using cash.*** *Anyone wanting a soft drink just needs to dial a number on the machine, and a can containing the thirst-quenching refreshment drops down. Soft-drink vending machines are* ***only one example of the use of novel applications*** *based on GSM (Global System for Mobile Communication)."* UMTS could be used in the same way, and will certainly be used for completely new applications.

Now we provide our own list of potential applications for UMTS, some of which already exist in the fixed network or 2nd generation mobile systems (e.g. GSM):

- Messaging: email, SMS
- Remote meter reading (water, electricity, gas)
- Monitoring: vending machines, arcade games
- Games: Interactive, multi-player
- Web browsing: WAP/HDML
- IP telephony
- Mobile workers: remote management and support of field service engineers or sales force
- ODMA: Transfer of ODMA packets to FDD infrastructure
- Automation: Process control, fire alarms
- Agricultural: control of machinery (e.g. remote controlled tractors), telemetry from sensors (soil condition, crop status), process control (irrigation, distribution of pesticides, herbicides)
- Meteorological: telemetry from sensors (temperature, humidity, rainfall etc)
- Security: intruder alarms, low rate CCTV (motion detection, object oriented coding , MPEG4, MPEG7), car anti-theft (alarm and tracking), tracking of children
- Financial: EFTPOS (electronic funds transfer at point of sale), authorisation, validation, credit checking, electronic money, electronic banking
- Transport: vehicle location (with GPS), tracking of secure loads, fuel monitoring (for fraud prevention), temperature monitoring (e.g. for frozen and chilled food), remote engine diagnostics, fleet management, dispatch services, road tolling
- Reverse channel for interacting with broadcast systems (e.g. DAB, DVB, satellite) , support for pay-per-view and subscriptions, home shopping, TV voting (e.g. what is your favourite X files episode?)
- Personal health monitoring: telemetry from sensors (heart rate, blood pressure, movement), monitoring for the elderly and disabled
- Sports: Telemetry from sensors (heart rate, blood pressure, location), support for training/performance assessment

DISCUSSION

The main question to be answered here is whether the aggregate load for all the applications requiring transmission of short-to-medium length packets within a cell is likely to be a significant fraction of the total uplink traffic load. In this case performance optimisation for such services is certainly worthwhile. We should also consider the loading of the RACH channel, where delay due to collisions is expected to be significant as the loading approaches 10% (i.e. around 1000 access attempts per second for the current RACH proposal [“Comparison of RACH and FAUSCH physical layer performance”, Tdoc SMG2 UMTS L1 530/98, from Philips]).

Clearly it is not possible to predict with any certainty the likely penetration for the applications considered earlier. It is also difficult to be sure of the traffic characteristics (e.g. packet arrival rates, packet sizes, and QoS requirements). However, we now select a few of the more interesting applications for further discussion, with some assumptions for user density and traffic loading presented in Annex A.

Telemetry. Many applications considered above are based on the transmission of data from sensors. In general the packet rate is likely to be equal to the rate at which sensor measurements are taken. For a single terminal this may not be rapid (e.g. remote control signal for an industrial process every second, location measurements every 10 seconds for a vehicle, or a reading from an electricity supply meter every 100 seconds). The amount of information per sensor reading may also be small (e.g. 8 bit temperature value, 40 bit position value). There is also likely to be significant header information required. For example, IP headers alone would require 20bytes per packet, although it should be possible to apply some compression. So if there were 300 radio terminals in a cell each connected to sensors generating a 200 bit packets every second (e. g. 100 data bits and 100 header bits), then the total uplink load would be 60kbps. This may not seem large, but is likely to be at least 6% of system capacity (see Annex B). Furthermore, if the RACH were used to support even this modest traffic level, there would be 300 access attempts per second, which would represent a significant loading of the RACH.

Interactive Games. Game playing represents a significant use for domestic PC’s. As PTSN and ISDN modem connections become more widespread, we expect to see the further spread of multi-player games. If the expected trend from fixed to mobile telecommunication connections continues, then such applications will appear on UMTS. We already see evidence of the start of this move of games onto mobile terminals [“Nokia 6110”, http://www.nokia.com/products/phones/phone_6110.html]. The characteristics of games related traffic will clearly depend on the specific example considered, and some are likely to be optimised for mobile use. For interactive games, of which Doom and Quake may be good examples, we expect the uplink data packets to be small, perhaps representing some key presses or a joystick position, but the latency is critical. As mentioned above the overhead from headers could be significant, even if compressed. The packet rate for a single user could be quite high, perhaps 10 per second. So with 300bit packets the average data rate for a single user would be of the order of 3kbps (with the peak somewhat higher). This is consistent with obtaining reasonable performance for such applications using a telephone modem. With 20 such users in a cell, the average uplink load would be 60kbps, and is likely to be at least 6% of system capacity (see Annex B). If the RACH channel were used for this there would be 200 access attempts per second, which is a significant loading. The packet failure rate/delay would have a significant impact for this application, so RACH performance would probably not be acceptable, due to collisions. The downlink might be provided on the FACH. An alternative to RACH/FACH would be to use a pair of DCH's. This would imply considerable loading in both uplink and downlink, and most of this would be due to the overhead needed to provide continuous power control in both directions**.**

UMTS with additional downlink resource. Currently it seems to be widely expected that the capacity of the UMTS downlink will be a limiting factor. However, the current downlink channels may be supplemented by UMTS extension bands, which are likely to be unpaired. This would increase uplink traffic in the existing channels. If TDD mode is deployed in FDD uplink bands (as envisaged by ERC TG1[Liaison Statement from CEPT/ERC Task Group1 on UMTS to ETSI SMG2]), the remaining FDD carriers would need to handle additional uplink traffic. Furthermore UMTS could be used to provide a return channel for broad-band broadcast systems (e.g. DAB, DVB, satellite, or local TV delivery systems). A wide variety of interactive services could then be offered. High penetration is certainly possible, but the traffic (e.g. short packets resulting from key presses on a remote control unit), would probably not justify use of dedicated uplink channels. However, the loading could be very peaky, for example during "TV voting" or in the few minutes before the start of a popular pay-per-view sporting event, where many viewers might wish to register within a short period of time. Games could also be supported by a video broadcast channel in combination with UMTS for the interactive component. In this scenario game services could generate a significant packet load on the UMTS uplink, without much load on the downlink.

CONCLUSIONS

We have seen a large number of possible applications, which require transmission of small-to-medium packets in the uplink, and where this traffic could be supported more efficiently using the FAUSCH concept than with RACH. Although no single application has been found which is likely to dominate the traffic, some could represent at least a few percent of uplink capacity. Therefore the total packet rate for all applications together could be significant fraction of the uplink traffic. Combining the loading suggested for just telemetry and interactive games leads to a loading of around 12% of uplink capacity and an aggregate bit rate of 120kbs. For comparison, in the scenario investigated, the total bit rate for voice telephony is around 240kbps. Furthermore the aggregate packet traffic would also lead to significant loading of the RACH. Therefore supplementing the RACH with FAUSCH will provide a useful increase in uplink capacity and reduce packet transmission delays.

Scenarios have been identified where the capacity of the UTRA FDD downlink will not be the limiting factor. One example is where UMTS is used as a packet based return channel for broadband services delivered using broadcast technology. Here the UMTS uplink capacity may become the limiting factor. In this case it will be worthwhile to improve the uplink performance for packet transmission by using FAUSCH.

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12. "Comparison of RACH and FAUSCH physical layer performance", Tdoc SMG2 UMTS L1 530/98, from Philips
13. "Nokia 6110", http://www.nokia.com/products/phones/phone_6110.html
14. "RTT Revision Performance Results", Tdoc SMG2 351/98
15. Liaison Statement from CEPT/ERC Task Group1 on UMTS to ETSI SMG2, December 1998

ANNEX A: USER DENSITY AND TRAFFIC LOADING

Some assumptions are needed to estimate the likely loading of UMTS for various applications. We take the following as a starting point for discussion:

Considering an urban area (e.g. similar to London, Paris, etc) we may have a population of 10 million in a circular area of radius 30km. This leads to a population density of about 3000 people/sq.km. Assuming that the average household is 3 people and that 1 in 5 of the population own or use a car or other vehicle, then the corresponding densities are 1000 homes/sq.km and 600 vehicles/sq.km. We know that the traffic would be divided among the available radio channels. We assume that 12 UMTS FDD channels are deployed with the same cell size and that the traffic is divided equally among them. This may not be realist since some operators will have a larger share of the market than others, and some channels may be used for large macro cells. On the other hand we do not specifically include the use of TDD mode and other systems (e.g. GSM and GPRS). We must also consider the penetration rate and activity factor for the particular applications.

Now, as a typical example we take a circular cell of 1.5km radius, which would have an area of about 7sq km, so this area would contain about 21000 people, 7000 homes and 4200 vehicles. In a cell of this size the maximum round trip delay between base station and terminal would be 10us. So if we allow a factor of 2 as a “safety margin” about 500 FAUSCH access slots could be allocated in a 10ms frame.

For telemetry from sensors, which might be deployed in homes and vehicles, we assume a penetration of 30% and an activity of 100%. That is 30% of homes and vehicles have some kind of sensor, which continuously transmits data via UMTS. Thus the number of active telemetry channels for a single UMTS radio channel in a single cell would be 0.3 x 11200/12 = 280.

For interactive games, let us assume a penetration rate of 10% per person and a busy hour activity factor of 10%. That is 10% of people have a terminal that can support interactive games on UMTS, and up to 10% of these terminals are active at one time (in the evening, or during a particularly interesting meeting?). Thus the number of active terminals running this kind of application for a single UMTS channel in a single cell would be 0.1 x 0.1 x 21000/12 = 18.

For comparison, it is of interest to obtain the likely loading for voice telephony. Let us assume 70% penetration of mobile telephony, of which 50% is carried by legacy systems (e.g. GSM!) and 50% by UMTS. With a 10% activity factor (i.e. 1 hour of telephone conversation in a 10 hour period) we reach 0.7 x 0.5 x 0.1 x 21000/12 = 60 calls in progress for a single UMTS channel in a single cell. This is consistent with current figures for UMTS system capacity in [“RTT Revision Performance Results”, Tdoc SMG2 351/98]. For an 8kbps voice codec with 50% activity factor, this represents a total uplink bit rate of about 240kbps.

ANNEX B: SYSTEM CAPACITY FOR UPLINK PACKET TRANSMISSION

For the scenarios considered in this document, simulation results for UDD64 are probably most applicable. For slow moving (or fixed) terminals the Pedestrian A environment seems appropriate. The uplink Eb/No from [“RTT Revision Performance Results”, Tdoc SMG2 351/98] is 1.5dB in this case. The spectrum efficiency is 340kbps/MHz/Cell, giving a total uplink capacity of about 1.7Mbps if all the uplink traffic were UDD64. This capacity figure assumes that the DCH is permanently allocated, and no overhead due to gaps between packets, so may be optimistic.

Results for various methods of packet transmission are given in [“Comparison of Eb/No for packet transmission using RACH and FAUSCH”, Tdoc SMG2 UMTS L1 623/98, from Philips]. Some were generated for the Indoor A environment, but would be almost identical for Pedestrian A. We see that the Eb/No for a packet size of 200bits is around 7.5dB for RACH (Short Packet), 4dB for RACH/FACH/DCH and 2.5dB for FAUSCH/FACH/DCH.

As an example we consider “small packet” applications with an aggregate packet rate in the uplink of 60kbps which would represent 0.06/1.7 or 3.5% of system capacity with an Eb/No of 1.5dB. However, if the date is transmitted as “isolated” packets, the required Eb/No is higher. Using the various methods discussed in [2] the fraction of uplink capacity would be 14% for RACH (Short Packet), 6% for RACH/FACH/DCH and 4.5% for FAUSCH/FACH/DCH. Therefore use of FAUSCH instead of RACH would save 1.5% of uplink capacity. If the packet rate were higher the savings would be of course be larger. Similar results are obtained for other services, but if the total system capacity is less than assumed here, then the relative savings from using FAUSCH will be greater.