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Agenda Item : AH24 : High Speed Downlink Packet Data Access

Source : Nortel Networks, Wavecom, France Telecom

Title : Stand-alone DSCH, proposed text for inclusion in TR 25.848 v 0.4.0

Document for : Discussion and approval

In the following some text related to a based stand-alone DSCH is proposed for inclusion in TR 25.848. The structure of the TR is reproduced here in order to provide a clear as to where the text should fit. New text of modification is marked with revision marks.

5. Overview of Technologies considered to support UTRA High Speed Downlink Packet Access

5.1 Adaptive Modulation and Coding (AMC)

5.2 Hybrid ARQ (H-ARQ)

5.3 Fast Cell Selection (FCS)

5.4 Multiple Input Multiple Output Antenna Processing

5.5 Stand-Alone DSCH

A stand-alone DSCH is defined as a DSCH mapped on a downlink carrier that is different from the carrier that supports its companion DCH.

Multiple cases can be considered as to where the stand-alone DSCH carrier is located:

1. The stand-alone DSCH carrier can be located in the already allocated paired band for FDD
2. The stand-alone DSCH carrier can be located in the newly identified paired bands for FDD, such as the 1.8 GHz band or the 2.5 GHz band
3. The stand-alone DSCH carrier can be located in the unpaired bands, currently not identified for UMTS

The introduction of independence between the frequency carrier supporting the DCH and the carrier supporting the stand-alone DSCH corresponds to an added flexibility with respect to R99 DSCH for which the DCH and DSCH are mapped onto the same carrier. The rationale for the stand-alone DSCH is multiple-fold:

?? It allows introducing carriers for the HS-DSCH at minimal impact onto carriers supporting existing services, as HS-DSCH would be introduced with an overlay network.
?? It allows to optimise/simplify the engineering for the HS-DSCH by minimising interaction with other services or adjusting the radio parameters for specific QoS characteristics.
?? By assigning up to whole carrier for the HS-DSCH, the maximum bit rate is further increased compared to a case in which the same carrier is used, as the DCH do not consume any bit rate on this carrier
?? It is one among other solutions to take advantage of unpaired spectrum, which may not be already identified for UMTS
?? By introducing multi-carrier cells, with a different number of carriers in up and downlink, this is a way to support highly asymmetrical services or asymmetrical load in a cell with minimum spectrum usage and/or hardware resource at the Node B; Also part of the overhead for the common channels is shared as one

frequency only carries all overhead channels (e.g. the BCH, FACH, PCH....) and the secondary carrier may carry only a sub-set of the overhead channels

?? The stand-alone DSCH allows considering new modulation apart from WCDMA, possibly better suited for DL, such as but no limited to OFDM. Relying on other modulation may even allow for usage of a different bandwidth apart from 5MHz in order to make the best use of any amount of free spectrum.

Stand-alone DSCH leads to the introduction of multi-carrier cells (on the downlink), where one carrier supports the DCH and all common channels (e.g. the primary frequency) and the second carrier (secondary frequency) supports as a minimum the stand-alone DSCH or DSCHs. Different cases of mobility management may be considered depending on when the different carriers are equivalent in terms of coverage or quality. In the event the different carriers are equivalent then mobility can be managed based on the primary frequency, otherwise both carriers are to be accounted for and hence monitored.

Two main options may be considered for the stand-alone DSCH :

?? A WCDMA based stand-alone DSCH

?? An OFDM based stand-alone DSCH.

For the WCDMA based stand-alone DSCH, there is a minimum impact onto the physical layer structure. Only the set of channels transmitted onto the secondary frequency is to be adjusted depending on the features used otherwise such DL Tx diversity, adaptive modulation and coding and mobility management and whether the channel estimation of a frequency different from the one of the DCH is performed on dedicated pilots or a common pilot. This is covered in more details in section 6 below.

OFDM may also be considered for the stand-alone DSCH. OFDM is a proven technology for broadcast services and local area networks and it offers high bit rate even for environment with high mobility. For the OFDM based stand-alone DSCH, the following physical channels might be introduced:

? an OPDSCH (OFDM Physical Downlink Shared Channel), which consists of an OPDSDCH (OFDM Physical Downlink Shared Data Channel) and possibly an OPDSCCH (OFDM Physical Downlink Shared Control Channel)

? an OSCH (OFDM synchronisation channel) which includes both possible CPICH functionalities and a possibly frame synchronisation

6 Proposed Physical Layer structure of High Speed Downlink Packet Access

6.1 Basic Physical Structure <frame length, update rates spreading codes, etc> for HS-DSCH

6.1.1 HSDPA physical-layer structure in the code domain

6.1.2 HSDPA physical-layer structure in the time domain

6.2 Basic physical layer structure for stand-alone DSCH

6.2.1 Physical layer structure for WCDMA based stand-alone DSCH

6.2.1.1. Structure in time and code domain

Principles for the time and code usage are the same as in the HS-DSCH on the same carrier as the DCH

6.2.1.2 Structure in frequency domain

In the frequency domain the principles are as follows:
The primary frequency in the cell carries the same transport and physical channels as in R99

The secondary frequency may transmit the following physical channels:

?? **None or one primary CPICH**, depending on activation of DL Tx Diversity with feed-back, use of a CPICH rather than dedicated pilots for channel estimation, use of a CPICH for the support of adaptive processes, such as adaptive modulation and coding and finally need to have CPICH based measurements for the handover
?? **None or one secondary CPICH :** depending on the activation of DL Tx diversity with feed-back
?? **One or multiple stand-alone PDSCH**
?? **None or one SCH channel:** depending on the existence of a fixed relationship between the synchronisation on the primary and secondary frequency**.** If one SCH is transmitted, a different set of SSC codes is to be used in order to avoid effect on the cell selection (the secondary frequency should not be mistaken to be a different cell).

Currently the assumption is that the secondary frequency would not transmit the PCCPCH and SCCPCH, as these would be carried over the primary frequency.

6.2.2 Physical layer structure for OFDM based stand-alone DSCH

6.2.2.1 Modulation

OFDM is a very efficient modulation in time and frequency dispersive environments e.g. in environments suffering from multi-path propagation and Doppler effect, especially when used with channel coding and interleaving (Coded OFDM). The same channel coding schemes as those defined for WCDMA can be used, e.g. convolutional code and turbo code.

The principle of OFDM is to split the high bit rate information to be transmitted over a large number of carriers, in such a way that the modulated symbols will be much longer than the delay spread. A guard interval (cyclic prefix) is also appended to each OFDM symbol. This makes the modulation intrinsically robust to multi-path. This multi-carrier modulation is also very spectral efficient.
Moreover, OFDM is efficiently implemented by the use of Fast Fourier Transform in the transmitter and receiver.

High data rates in various environment conditions can be achieved by the use of OFDM modulation.
Solutions that are already under consideration for HSDPA, e.g. AMC, H-ARQ, FCS and MIMO antenna processing are compatible with OFDM and can be combined to them to reach for still higher data rates and more efficient transmissions.
Bandwidth of more than 5MHz can also easily be considered.
Moreover, OFDM spectral efficiency can be further increased by shaping each sub-carrier with a prototype function optimally localized in the time and the frequency domains.

The OFDM modulation is characterized by a few parameters that may be optimised with regard to the propagation environment and to the system requirements. Different sets of parameters, say Nc, may be defined, each corresponding to a physical channel, which is then characterized by the set of values $(T_S, ??_0)$, where T_s is the symbol duration and v_0 the inter-carrier spacing. This optimisation makes the transmission more efficient and can be interpreted as another degree of freedom for the radio link adaptation given by the AMCS.
Of course, Nc can also equal 1, i.e. one set of parameters for all propagation conditions. This set of parameters corresponds to the worst propagation case, in terms of Doppler effect and delay spread.

6.2.2.2. Physical channels structure

6.2.2.2.1 Structure in time and frequency domain

Whereas in the HS-DSCH on the same carrier or WCDMA based stand-alone, the radio resource is shared between users in codes and time domain, for the OFDM based stand-alone, the resource is shared in frequency and time domain. Narrow band carriers are allocated in blocks (corresponding to adjacent carriers) of adjustable sizes. A user may get one or multiples blocks.

6.2.2.2.2.List of physical channels

Two physical channels may be considered:

?? OFDM Physical Downlink Shared Channel (OPDSCH)

?? OFDM synchronisation channel OSCH

The OPDSCH (OFDM Physical Downlink Shared Channel) corresponds to a block of narrow band carriers, allocated for a time interval corresponding to the smallest granularity, e.g. the smallest Transmission Time Interval of the corresponding Code Composite transport channel (CCTrCH). The OPDSCH corresponds hence to a set of OFDM symbols, in time and frequency. Some of these symbols are data symbols whereas others correspond to pilot symbols. The OPDSCH is hence made of OPDSCCH (OFDM Physical Downlink Shared Control Channel) and of a OPDSDCH (OFDM Physical Downlink Shared Data channel) in a similar way as a Dedicated Physical Channel is made of the DPCCH and DPDCH in WCDMA.

The OSCH (OFDM synchronisation channel) is a common channel providing CPICH functionalities and possibly frame synchronisation.

?? It may be required for the support of DL Tx Diversity with feed-back and for the support of adaptive processes such as adaptive modulation and coding and measurements to help mobility management (Mobile assisted Handover). As an alternative to an OSCH based measurement for the support of AMC and quality based scheduling, we can have knowledge of the radio link quality thanks to the channel estimation obtained with the dedicated pilots.

?? No specific time and frequency initial synchronisation is needed as initial synchronisation of the UE can be performed by using the synchronisation information obtained for the DCH and common channels. If tracking is required, depending on the total length of the OFDM blocks transmitted, the dedicated pilots used for channel estimation can be used to keep the UE synchronised. Frame synchronisation can also be recovered from the information obtained for the DCH and common channels. However a proper frame synchronisation may be required in case of handover during an OFDM reception.

6.2.2.2.2 Structure in frequency domain

In the frequency domain the principles are as follows:

The primary frequency in the cell carries the same transport and physical channels as in R99.

The secondary frequency may transmit the following physical channels:

? **None or one OSCH** (including both possible CPICH functionalities and a possibly frame synchronisation): depending on activation of DL Tx Diversity with feed-back, use of an OSCH for the support of adaptive processes such as adaptive modulation and coding, use of an OSCH based measurements for the support mobility .

.? **One or multiple stand-alone PDSCH**

Currently the assumption is that the secondary frequency would not transmit OFDM channels equivalent in functionality to the PCCPCH and SCCPCH, that is to say physical carrying BCH, FACH or PCH transport channels, as these would be carried over the primary frequency.

7. Evaluation of Technologies

7.1 Adaptive Modulation and Coding (AMC)

7.2 Hybrid ARQ (H-ARQ)

7.3 Fast Cell Selection (FCS)

7.5 Multiple Input Multiple Output Antenna Processing

7.6 Stand-alone DSCH

7.6.1 Performance evaluation

7.6.1.1 WCDMA based Standalone DSCH

The WCDMA stand-alone DSCH is very similar to the HS-DSCH on the same carrier as the DCH. Provided the small amount of difference, it is expected that the achievable bit rate and throughput per carrier for the stand-alone DSCH when combined with the other concepts evaluated above (AMC, FCS and HARQ) is similar or higher compared to the HS-DSCH on the same carrier, with the only difference that the DCHs do not eat up part of the capacity leading hence to a possibly higher peak bit rate for the stand-alone DSCH.

7.6.1.2 OFDM based stand-alone DSCH

While using QPSK, which is a very robust modulation, and with a coding rate of 3/4, the OFDM stand-alone DSCH allows to achieve around 7 Mbps user bit rate in 5 MHz. This figure is based on an example of optimized parameters that is proposed in Section 12. This data rate has to be compared to the 2Mbps offered with WCDMA technique.

This net bit rate can still be increased while using higher order modulations and, if needed, coding rate. For instance, using 16 QAM instead of QPSK (while coding rate is still 3/4) leads to 14.4 Mbps in 5 MHz. In other words, a link adaptation concept, based on adaptive modulation and coding scheme (AMCS) can be considered for the OFDM modulation .

Moreover, larger bandwidth can also easily be considered. For instance using QPSK in 20 MHz leads to a peak bit rate of 26 Mbps.

In addition those bit rates are still available in a real mobile environments up to vehicle speed of 250 Km/h. Moreover, OFDM is compatible with other possible enhancements addressed for HSDPA (HARQ, AMC, MIMO, FCS), and the combination of these techniques could allow achieving still higher data rates.

7.6.2 Complexity

7.6.2.1 UE's complexity for WCDMA based Stand-alone DSCH

?? A second receiver or part of the receiver is to be duplicated as the DSCH is located onto a separate carrier. Some of the base-band processing capability may indeed be shared between the processing of f1 and f2, as only the channel estimation needing to be effectively duplicated separate. The UE capability for the channel decoding, de-multiplexing.... may be shared between the DCH and DSCH as in R99.

?? That second receiver may be considered as an evolved version of a second receiver which is referred to for UEs which do not required compressed mode for the inter-frequency measurements, when the Stand-alone is mapped onto the existing FDD band.

?? The impact of the second receiver introduction depends on the frequency band that is used.

7.6.2.2 UE's complexity for an OFDM based stand-alone DSCH

7.6.2.2.1 Hard-ware architecture

The UE must be able to demodulate both the WCDMA and the COFDM received signals.
Additional complexity is given in terms of silicon surface.
The services taken into account are voice and data (fast internet, home shopping, banking, video on demand..). A dedicated processor whose existence is not related to the use of OFDM over the stand-alone DSCH performs special applications such as video conferencing.
Hardware complexity notably depends on the channel estimation technique used.
The silicon reference area corresponds to a base-band component performing WCDMA, GSM and GPRS.

For a 100 mm2 reference component and a channel estimation performed per block by using scattered pilots and a two-dimensional interpolation technique, it was evaluated that the additional silicon area due to OFDM is only 3.5%.

7.6.2.2.2. Radio architecture

The UE radio architecture depends on the impacts of the WCDMA transmission and reception on the OFDM reception and vice versa.

<u>RX WCDMA and RX OFDM</u>:
While using SAWs one can couple the two bands at the stage of the duplexer.

<u>TX WCDMA and RX OFDM</u>:
Depending on the distance between the TX WCDMA band and the stand-alone band the following scenarios are possible:

- one antenna is sufficient (large enough separation)
- 2 antennas or one antenna with a specific duplexer (close bands).

These conclusions are obviously to be re-examined according to the progress of radio technologies.

12 Annexe Simulation Assumptions and Results

For the OFDM based stand-alone DSCH.

12.1 Link level simulation parameters

12.1.1 OFDM parameters

Physical Channel	Type 1	Type 2	Type 3
UMTS propagation conditions (vehicle speed: km/h)	Indoor A (3, 10) Indoor B (3, 10) Out-In A (3, 50, 120)	Out-In B (3, 50, 120) Vehicular A (50, 120, 250)	Vehicular B (50, 120, 250)
3GPP propagation conditions*	Cases 1, 3, 4, 5		Case 2
Useful symbol duration T_u (?s)	15.625	78.125	140.625
Guard interval duration T_g (?s)	1.04	5.2	26.04
T_g / T_u (%)	6.7	6.7	18.6
Overall symbol duration $T_s = T_u + T_g$ (?s)	16.67	83.325	166.67
Carrier separation $?_0$ (kHz)	64	12.8	7.11
FFT size	120	600	1080
Number of sub-carriers	80	400	720
Number of OFDM symbol per frame (10 ms)	600	120	60
Constellation	QPSK	QPSK	QPSK
Channel bit rate	9.6	9.6	8.625

Table 1 : OFDM physical channel parameters according to the propagation environment

(*): In this example, system parameters were optimized regarding UMTS propagation conditions. However, these parameters can be used for 3GPP cases as indicated in Table 1.

Examples for the channel coding parameters for the performance evaluation are :

Physical Channel	Type 1	Type 2	Type 3
Coding rate	3/4	3/4	4/5
Channel bit rate	9.6	9.6	8.625
User bit rate**	7.2	7.2	6.9

Table 2 : Proposed coding schemes

(**): In this example, the overhead represented by the pilot symbols is not accounted for. This will typically represent 10% of the bit rate.

12.1.2 Simulation parameters

The table 2 below summarizes the link level simulation assumptions.

Parameter	**Value**	**Comments**
Carrier frequency	Around 2 GHz	To be defined
Sampling Frequency	7.68 MHz	
Channel bandwidth	5 MHz	
Propagation condition	AWGN, IB10, OIA50, OIA120, OIB120, VA50, VA250	Worst cases than the defined environments in TS 25.201 and TS 25.202. Others results will be given

		considering the more favourable propagation models given in those two TRs.
Vehicle speed	10/50/120/250 km/h	
HSDPA frame length	10 ms	
Channel Estimation	Ideal	First step
Fast fading model	Jakes spectrum	Generated by Jakes
Symbol period	C.f. table 1 in § 2.2.1	
Inter-carrier spacing	C.f. table 1 in § 2.2.1.1	
Channel coding	Convolutional code (K=7, [133, 171])	Turbo-code : to be simulated
Channel code rate	3/4 and 4/5 for Vehicular B	Channel code rate will vary depending of the desired throughput (AMCS)
Interleaving depth (TTI)	3.33 ms (5 slots)	First step; 10 ms to be simulated
Number of bits per symbol constellation	2 (QPSK)	Higher level constellation can be achieved, depending on the required throughput e.g. depending on the service (AMCS).
Pilot energy / data symbol energy	$\frac{E}{e} ? \sqrt{N ? 2}$	N is the number of data symbols per pilot symbol.
Number of simulated bits	10 and 50 km/h: 10 Mbits 120 and 250 km/h: 5 Mbits	
Information bit rate	6 Mbps at least	

Table 2: link level simulation assumptions

In addition, we may notice that the channel variation (due to Doppler) was simulated in a continuous way. Namely, the channel is modelled as

$$r(t,?) ? \sum_{i?0}^{Npath?1} c_i(t).s(? ? ?_i) ? n(?) ,$$

whereby $n(?)$ is the Gaussian noise, $s(?)$ the transmitted signal, $r(t,?)$ the received signal and, for each path, $c_i(t)$is a complex Gaussian process correlated in time according to the Doppler spectrum (the c processes are independent from each other). This coefficient can, for instance, be modelled as white Gaussian noise filtered by a Doppler filter.

12.2 Link level simulations results

Figures 1 and 2 present COFDM performances, in terms of BER/FER versus C/N ratio.

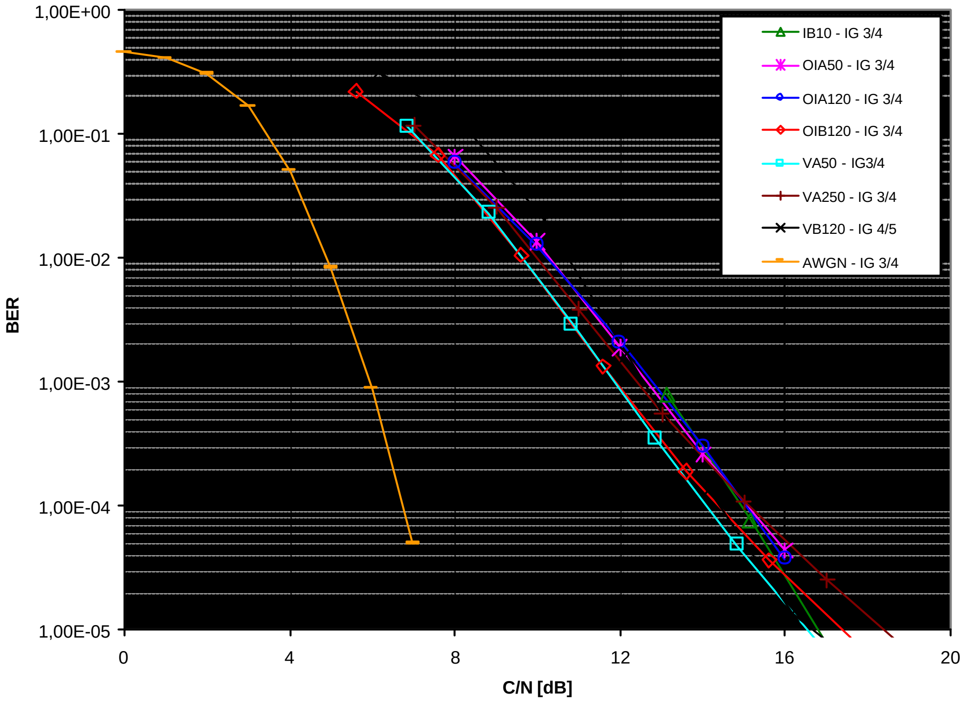

Figure 1: COFDM performances on UMTS propagation channels

Environment propagation	C/N (dB)
AWGN	6.3
IB 10	14.9
OIA 50	15.1
OIA 120	15.1
OIB 120	14.4
VA 50	14.1
VA 250	15.1
VB 120	14.4

Table 4: Performances of a COFDM system for a BER of 10^{-4}

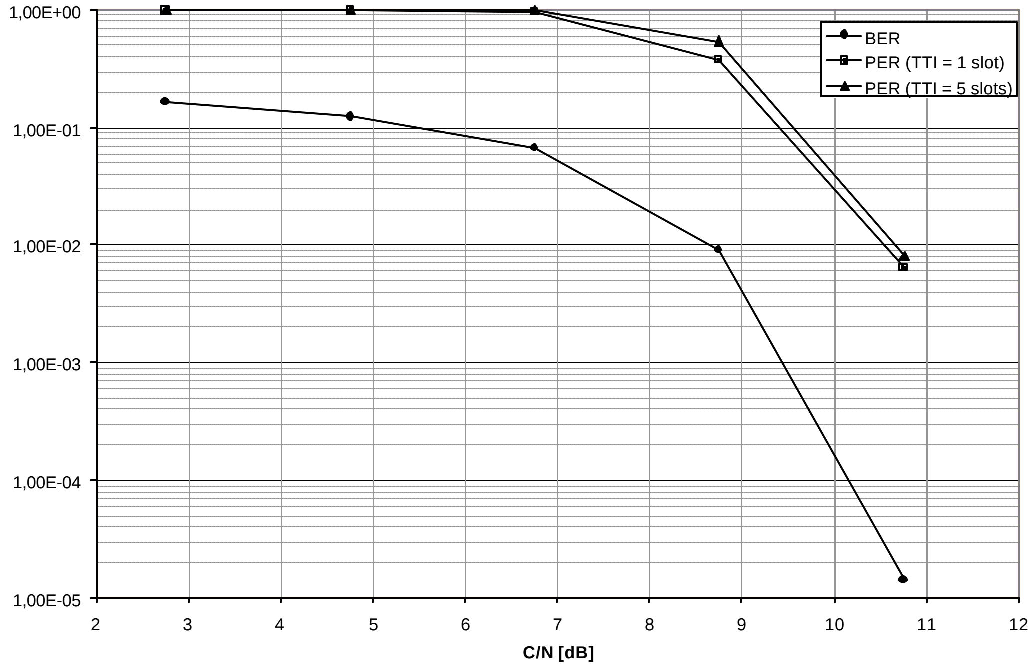

Figure 2: COFDM performances on 3GPP Case 3 propagation channel