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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
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Contents

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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE 1: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

European Broadcasting Union
CH-1218 GRAND SACONNEX (Geneva)
Switzerland
Tel: +41 22 717 21 11
Fax: +41 22 717 24 81

The Eureka Project 147 was established in 1987, with funding from the European Commission, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers. Their work resulted in the publication of European Standard, EN 300 401 [1], for DAB (see note 2) which now has worldwide acceptance.

NOTE 2: DAB is a registered trademark owned by one of the Eureka Project 147 partners.

The DAB family of standards is supported by World DMB, an organization with members drawn from broadcasting organizations and telecommunication providers together with companies from the professional and consumer electronics industry.

1 Scope

The present document defines rules of implementation for certain service information features. These rules have been developed to provide a reliable and consistent experience for digital radio listeners; they provide implementation details for how the FIC signalling is used and how receivers will interpret and behave in response to receiving the FIC signalling. The rules defined in the present document supersede the informative guidance given in TR 101 496 [i.1] for the FIGs contained herein. In addition, some clarifications are provided for EN 300 401 [1] where a number interpretations may appear equally valid: in each case this is mentioned specifically. Future versions of EN 300 401 [1] will be modified to include these clarifications.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 401: "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 101 496 (all parts): "Digital Audio Broadcasting (DAB); Guidelines and rules for implementation and operation".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Change Event Indication (CEI): set of FIG fields with particular values to indicate a change of database content for certain service information features

database entry: part of the service information addressed by a database key

database key: set of FIG fields that sub-divide a database for certain service information features

linkage set: description of a network configuration consisting of lists of identifiers which carry the same (hard link) or related (soft link) content

service following: maintaining the same audio or data content that the user has selected in spite of the varying reception conditions that occur, for example, when travelling by car or train

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAC	Advanced Audio Coding
AM	Amplitude Modulation
AMSS	Amplitude Modulation Signalling System
C/N	Current/Next
CAId	Conditional Access Identifier
CEI	Change Event Indication
DAB	Digital Audio Broadcasting
DMB	Digital Multimedia Broadcasting
DRM	Digital Radio Mondiale
ECC	Extended Country Code
EId	Ensemble Identifier
F	Frequency
FI	Frequency Information
FIB	Fast Information Block
FIC	Fast Information Channel
FIG	Fast Information Group
FM	Frequency Modulation
Id	Identifier
IdLQ	Identifier List Qualifier
ILS	International Linkage Set
LA	Linkage Actuator
LSN	Linkage Set Number
LTO	Local Time Offset
MFN	Multi-Frequency Network
MPEG	Moving Pictures Expert Group
MSC	Main Service Channel
OE	Other Ensemble
P/D	Programme/Data service flag
PI	Programme Identification code (RDS)
R&M	Range and Modulation
RDS	Radio Data System
Rfa	Reserved for future addition
Rfu	Reserved for future use
S/H	Soft/Hard
SFN	Single Frequency Network
Shd	Shorthand indicator
SId	Service Identifier
TII	Transmitter Identification Information

4 Overview of service information FIGs

Service information in DAB is carried in the Fast Information Channel (FIC) as a series of Fast Information Groups (FIGs) carried in Fast Information Blocks (FIBs). Different FIGs are used for different service information, and several different FIGs may be needed to implement a particular service information feature, such as service linking or announcements. The present document provides rules of implementation for service information ***features*** and so groups the usage of the required FIGs together. Some FIG types are used by a number of different features and the rules are designed so that the FIG is always coded and decoded consistently.

Service information in DAB essentially fits into two categories: unique information and list information. The unique information category includes the service component language: each time the service component language is decoded, a receiver knows that it shall replace whatever it has stored with what is received because a service component can only have one language set at any given time.

The type 0 FIGs in the unique information category are as follows:

- FIG0/5 - service component language, [1] clause 8.1.2;
- FIG0/10 - Date and Time, [1] clause 8.1.3.1;
- FIG0/13 - User application information, [1] clause 8.1.20;
- FIG0/16 - Programme Number, [1] clause 8.1.4;
- FIG0/17 - Programme Type, [1] clause 8.1.5;
- FIG0/19 - Announcement switching, [1] clause 8.1.6.2;
- FIG0/26 - OE announcement switching, [1] clause 8.1.10.5.2;
- FIG0/28 - FM announcement switching, [1] clause 8.1.11.2.2;
- FIG0/31 - FIC re-direction; [1] clause 8.1.12.

The list information category includes the list of frequencies for an ensemble, or a list of ensembles which carry a service. This type of information has a variable number of items in the list, and there may be more than one list, since there may be several ensembles or services, or whatever. DAB handles the transfer of this kind of information from ensemble provider to receiver by use of FIGs using a database mechanism.

The type 0 FIGs in the list information category are as follows:

- FIG0/6 - service linking information, [1] clause 8.1.15;
- FIG0/9 - Country, LTO and International table, [1] clause 8.1.3.2;
- FIG0/11 - Region definition, [1] clause 8.1.16.1;
- FIG0/18 - Announcement support, [1] clause 8.1.6.1;
- FIG0/21 - Frequency Information, [1] clause 8.1.8;
- FIG0/22 - TII database, [1] clause 8.1.9;
- FIG0/24 - OE Services, [1] clause 8.1.10.2;
- FIG0/25 - OE Announcement support, [1] clause 8.1.10.5.1;
- FIG0/27 - FM Announcement support, [1] clause 8.1.11.2.1.

The total set of information for each FIG is called a database, but since it may carry information from different service providers, it is divided into smaller portions to allow better management. Each portion of the database is addressed by the use of a database key so that it may be updated independently of the rest of the information. The database key is defined for each FIG and the information addressed by the database key is called a database entry.

The information carried by FIGs using the database mechanism is generally very stable, often relating to a transmitter network configuration. Since it is unknown when any particular receiver will tune to a DAB ensemble, the information needs to be transmitted cyclically. Each FIG using the database mechanism has a long form for carrying database entries and a short form for signalling that changes are to be made to a particular database entry.

Each database entry may require many FIGs to completely signal all of the information. The first FIG carrying information for a particular database entry is signalled with the C/N flag in the FIG type 0 header field (see [1], clause 5.2.2.1) as the "start of database" entry; all subsequent FIGs needed to complete the database entry are signalled as "continuation of database" entries.

Over time, database entries will need to be changed, and this is done by means of the short form of the FIG - the Change Event Indication (CEI), which is defined separately for each FIG. The CEI mechanism works by sending a burst of short form FIGs to alert receivers of imminent changes. The short from is transmitted once per second for five seconds. When a database entry is changed, it is generally useful to send the new information for that entry more quickly than the overall repetition cycle for that database.

The FIG type 0 header field also contains the Other Ensembles (OE) and Programme/Data (P/D) flags. The OE flag is used to indicate if the information carried is for a service in the tuned ensemble or another ensemble. The P/D flag is used to indicate if the information is for a programme (audio) service or a data service. It is not possible to mix start of database with continuation of database, tuned ensemble and other ensemble information, or audio service and data service information within a single FIG since the three header flags apply to all the information in the FIG.

5 Service following

5.1 Introduction

Service following is the term applied to maintaining the same audio or data content that the user has selected in spite of the varying reception conditions that occur, for example, when travelling by car or train. Many broadcast network topologies are possible, and the tuned service may be carried on an ensemble with multiple tuning frequencies, on more than one ensemble, may carry common programming with other DAB services, and for audio services, also be carried on FM-RDS or another bearer. The best service following experience for the listener is achieved when the broadcaster minimises the timing differences between different bearers, taking into consideration the different coding and decoding delays of the different systems. Reliable service following also requires that all the identifiers used are properly allocated in such a way as to make them unique within their respective scope.

DAB provides signalling that enables service providers to inform receivers about the broadcast networks and service configurations that allow service following to take place (much of which is static, since it refers to transmitter network configurations that change only infrequently), and also provides dynamic information to control which of that information is used at any given time to take account of changes during the day. Three types of information may be involved with service following - service linking information, Other Ensembles Services information and Frequency information. Service following generally provides information to allow precisely the same service to be followed, and when linking information is needed this is called hard linking. Service providers are also able to indicate suitable alternative content - related services - and this is called soft linking. Receivers shall investigate all possible hard links before checking for soft links, and since the content is not identical for a soft link, shall request user intervention before following the link.

Figure 1 shows the FIGs used for service following.

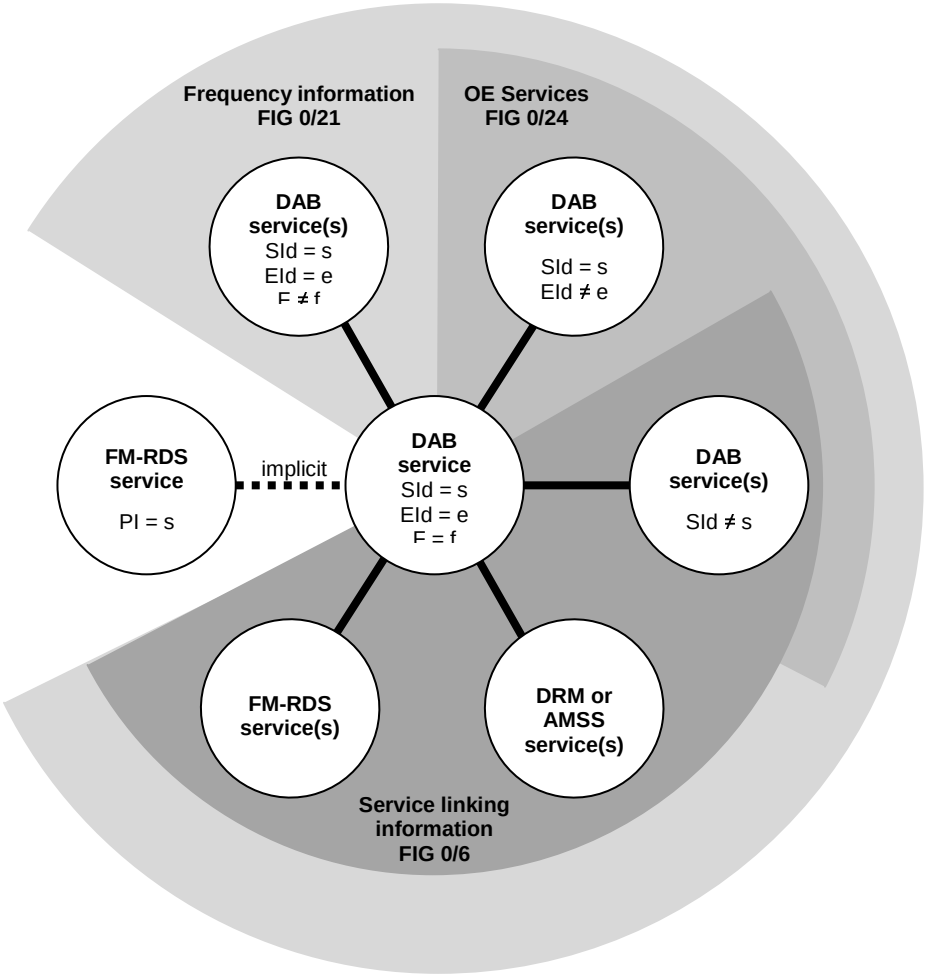

Figure 1: Service following and supporting FIGs

The DAB service at the centre of figure 1 represents the tuned service and it may have one or more of the alternate sources represented by the surrounding circles.

5.1.1 Service linking information

Service linking information allows the service provider to establish one or more sets of identifiers that carry identical, in the case of a hard link, or related, in the case of a soft link, content. The set of identifiers is called a linkage set. There may be several linkage sets that are valid at different times of day. Each linkage set is identified by the Linkage Set Number together with a set of flags, and by use of the Linkage Actuator, linkage sets can be activated and deactivated.

The receiver uses these linkage sets during service selection and following to determine a set of candidate services, potentially on different bearers, that are equivalent or related to the selected service. The receiver selects an appropriate service from these candidates based on criteria such as service availability and quality.

Receivers may cache linkage sets for services of interest (e.g. the currently selected service and other recently or frequently selected services) across power cycles, radio frequencies and locations so that the information is available immediately when the receiver is turned on and when it switches from one radio frequency to another. The benefits of caching may be negated if different ensembles carry inconsistent or incomplete linkage sets. It is therefore important that linkage sets are signalled completely and consistently (including the state of the Linkage Actuator) in all locations and on ensembles carrying any of the linked services.

5.1.2 OE Services

In order to assist the receiver, the service provider may signal a list of geographically adjacent alternative ensembles using FIG0/24 on which the current and other services can be found.

The receiver may use this information to identify ensembles carrying a service when it is selected by the user and during service following. This may reduce the number of radio frequencies that a receiver scans before it locates an ensemble carrying the service. This helps minimise the time delay between the user selecting a service and the start of audio output, particularly when selecting a service on another ensemble in a mobile environment. It also helps minimise the duration of any interruption to the audio output when service following occurs, especially in single tuner receivers.

It is therefore recommended that service providers signal OE Services to enable the best possible user experience during service selection and following. This information is especially useful when provided together with Frequency Information for other ensembles in the same or an adjacent coverage area.

5.1.3 Frequency information

In order to assist the receiver, the service provider may signal a list of alternative frequencies using FIG0/21 on which the current ensemble and other ensembles may be found. FIG0/21 may also signal frequency information for other bearers such as FM-RDS, DRM and AMSS.

The receiver may use this information to identify frequencies carrying an ensemble during service selection and service following. It may also use it to identify frequencies carrying linked FM-RDS, DRM or AMSS services during service following. This may reduce the number of frequencies that the receiver scans before it locates a service when it is selected by the user and during service following. This helps minimise the time delay between the user selecting a service and audio output and, especially in single-tuner receivers, the duration of any audio interruption during service following.

It is therefore recommended that service providers signal Frequency Information to enable the best possible user experience during service selection and following. This information is especially useful when provided together with OE Services for other ensembles in the same or an adjacent coverage area.

Where the same ensemble is available on different radio frequencies with overlapping coverage areas, it is also advantageous for the transmissions to be synchronised and for the continuity flag to be signalled in the frequency information. This enables the receiver to maintain continuous audio output during service following without any re-synchronisation delay in the de-interleaver and audio decoder.

5.2 Service linking

The FIG0/6 consists of a header field and one or more service linking fields.

The service linking fields can take the short form or the long form and this is determined by the state of the Id list flag.

The database key for FIG0/6 consists of the OE and P/D flags from the header field and the S/H, ILS, and LSN fields from the service linking field.

In the preparation of these rules of implementation it was decided that some functionality permitted by EN 300 401 [1] should not be used. Therefore, the situation where OE = 1 shall not be signalled, although receivers should still check that this bit is set to 0 since it may be redefined in the future. The IdLQ field shall not take the value 10 since indicating services without the ability to identify themselves does not produce a good user experience. The situation where Shd flag = 1 shall not be signalled; instead each identifier shall be explicitly listed.

5.2.1 Short form - Activation state and change event indication

The short form has the Id list flag set to 0. It is used for signalling change: either change to the state of the Linkage Actuator (LA) flag of a linkage set or changes to the database content of a linkage set. The C/N flag in the FIG0/6 header is used to determine which type of change is being signalled.

When a service provider wishes to change the state of the LA flag - to activate or deactivate service following within a linkage set - the C/N flag is set to 1.

NOTE: This use of the C/N flag is not clearly described in EN 300 401 [1].

When a service provider wishes to change the content of the database associated with a particular linkage set - due to a network configuration change, for example - the C/N flag is set to 0.

Therefore it is not possible to indicate both types of change in the same FIG0/6 field; if both changes are required then separate FIG0/6 fields need to be sent with the C/N flag set correctly. However, it is possible to indicate the change of the LA flags for multiple linkage sets in one FIG0/6 field, and indeed this is required when a service changes which other services it is grouped with and so one linkage set is de-activated and another is activated (see clause 5.2.4.3).

5.2.2 Long form - Database definition

The long form has the Id list flag set to 1. It is used to build up the database of identifiers that are linked together to form linkage sets. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database definition requires a service linking field with a start of database indicator; depending on the number of bearers and number of identifiers, there may be one or several service linking fields with a continuation of database indicator. There shall be only one service linking field for the start of database for each database key.

NOTE: It is not possible to mix start of database definition and continuation of database definition service linking fields in the same FIG since the C/N flag applies to the entire FIG.

Each bearer requires a separate service linking field since it is identified by the IdLQ field. The order of identifiers signalled in the linkage set has significance. All DAB SIds shall be signalled first (IdLQ = 00), followed by all FM-RDS PI codes (IdLQ = 01) and finally service identifiers for DRM and AMSS (IdLQ = 11).

The sole exception is when there is a **single** DAB SId in the linkage set. In this case there is no need to signal the DAB SId separately since "when the version number of the type 0 field is set to "0" (using the C/N flag, see clause 5.2.2.1), the first entry in the Id list of each Service linking field shall be the SId that applies to the service in the ensemble". EN 300 401 [1] clause 8.1.15.

The order of transmission of the identifiers shall be kept constant so that receivers may build confidence in the information they store.

To allow receivers to determine quickly if the service linking information in any particular linkage set is of interest, when there is more than one SId in the linkage set, all the SIds for services carried in the current ensemble shall be transmitted in the FIG indicating the start of database (C/N = 0, IdLQ = 00).

5.2.3 Linkage sets

A linkage set is a collection of identifiers (DAB SIds, RDS PI codes, etc.) that correspond to alternative sources of the same content (hard link) or similar content (soft link) - effectively a linkage set represents a particular transmission network configuration and so is essentially static. However, a particular service may have different alternative sources at different times of the day. Each of these different situations can be represented by a different linkage set, each corresponding to a particular network configuration.

The linkage set representing the current network configuration is activated, whilst all other linkage sets for that service are deactivated. A linkage set may be activated for 24 hours a day (and so represents the *only* network configuration for that service), or may be activated for only 30 minutes on weekdays, for the duration of an advertisement break, or any other such time period. Each linkage set is uniquely identified by a combination of flags and the Linkage Set Number (LSN). The LSNs shall be co-ordinated between all broadcasters in a particular country such that they are unique in combination with the flags. The activation state of all the defined linkage sets in the ensemble is signalled every 10 seconds, and more frequently when changes are made. When a linkage set is activated receivers may switch to one of the alternate sources of the content; when it is deactivated they shall not. This feature allows service providers to signal linkage sets in advance of their use and control the receiver linkage behaviour by changing the state of the LA flag for each linkage set.

EXAMPLE 1: A service provider has a service carried on four geographically adjacent DAB ensembles. For most of the day, the audio content is the same throughout the total coverage area of the four ensembles, but for four hours in the morning and three hours in the evening he produces different content for each ensemble area. When the audio content is identical the service provider wants receivers to freely switch between the ensemble areas so that a mobile listener (in a car or train) gets continuity throughout his journey, but when the audio content is different, the service provider does not want receivers to switch since they would then be playing different audio and this would be very annoying in the overlap zone between ensemble areas as the signal strength variation favours one and then another ensemble. Since the content is not identical throughout the day, the service will have a different SId on each of the four ensembles. By signalling a linkage set with all four SIds and using the LA flag, the service provider can signal to receivers when to link the services and when not to. This example is explored in more detail in clause A.3.

The linkage set definitions reflect different broadcast network configurations. If for a particular service, the alternative sources remain the same throughout the day, week and year, then only one linkage set is needed and it will be activated at all times. For other services there may be different alternatives at different times of day that reflect the programming needs of the service provider. Each broadcast network configuration can be represented by a different linkage set, and each of these should be defined and allocated an identifier - the LSN in combination with certain flags. As the day progresses and each configuration becomes valid, a different linkage set is activated to inform receivers of the valid alternatives. In this way the database information built up by the receivers remains static, but the validity of a particular broadcast network configuration is controlled dynamically by indication which linkage set is active.

The database key for FIG0/6 consists of the OE and P/D flags from the header field and the S/H, ILS, and LSN fields. Eight different types of linkage sets are available and these are differentiated by use of three flags: the P/D flag, the Soft/Hard (S/H) flag and the International Linkage Set (ILS) flag (rather confusingly, all eight types use the LSN field to carry the Linkage Set Number, so it is essential to always correctly set and determine the state of the P/D, S/H and ILS flags in combination with the LSN when assembling the databases. Also note that the OE flag, whilst part of the database key - and therefore used to divide the database into manageable pieces - does not create separate linkage sets for tuned and other ensembles.). This means that there are four Programme (audio) and four Data linkage sets, each having Hard National linkage sets, Soft National linkage sets, Hard International linkage sets and Soft International linkage sets. In fact the terms National and International can be misleading - the ILS flag for programme (audio) services switches between 16-bit fields and 24-bit fields for identifiers.

A service can only be active in one Hard linkage set and active in one Soft linkage set at a given time. A service can only be active in either a National Linkage set or an International Linkage Set at a given time.

Linkage sets may contain identifiers for services transmitted using DAB, FM (with RDS), DRM, and AM (with AMSS). These different bearers are distinguished by use of the Identifier List Qualifier (IdLQ) field, and each bearer requires a separate service linking field (or fields if there are many identifiers to signal).

EXAMPLE 2: A service provider has services with identical audio content for a particular period on two DAB services and three FM services, all with different audio content at different times and he wishes to link them together. He transmits a service linking field with the C/N flag = 0 [start of database] with the IdLQ set to 00 [DAB SIds] with Id1 and Id2 indicating the SIds of the two DAB services, and transmits a second service linking field with the C/N flag = 1 [continuation of database] and the IdLQ set to 01 [RDS PI codes] with Id1, Id2 and Id3 indicating the PI codes of the three FM-RDS services.

Implicit linking requires no service linking information to be sent. It provides the equivalent case to an activated hard linkage set in which the only entries are a DAB SId and an RDS PI code with the same value. This linkage set exists for all DAB services unless it is deactivated by defining and activating a hard linkage set which includes a service linking field with IdLQ = 01 [RDS PI codes]. Such a linkage set may contain zero PI codes in which case all service following to FM-RDS is prevented (the so called "dead link").

NOTE: If a network configuration exists where the DAB SId is linked to more than one PI code but includes the PI code that has the same value as the DAB SId, then the defined linkage set will include that PI code too.

5.2.4 Signalling a link

There are different phases to signalling a link. The database shall be defined (using the long form), activated and deactivated (using the short form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.2.4.1 Defining and redefining a linkage set

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database is about to be defined (a redefinition is simply a definition of an existing linkage set with changed content).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form service linking field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, S/H flag, ILS flag, and LSN - defining which database entry of the linking database is being changed.

Next, the database definition begins using the long form service linking field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database, these are sent with C/N set to 1. The complete database entry for each database key should be transmitted within 10 seconds.

Services in the current ensemble shall be signalled in the FIG0/6 service linking field which indicates the start of database; this enables receivers to determine quickly if the linkage set is of interest or not. The other identifiers follow, in any order.

5.2.4.2 Maintaining the linkage set

Once defined, the identifiers in each linkage set shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information. The state of the LA flag shall always be consistent with the activation state of each linkage set on each repetition.

The activation state of the defined linkage sets are signalled by using the short form of the service linking field with the C/N flag set to 1. The activation state of all the linkage sets in the database shall be signalled every 10 seconds.

5.2.4.3 Changing the activation state of linkage sets

Defined linkage sets are activated and deactivated by using the short form of the service linking field with the C/N flag set to 1. Each service can only be in one activated hard linkage set and in one activated soft linkage set at any one time (although can feature in several deactivated hard linkage sets and several deactivated soft linkage sets).

When a network configuration change needs to be signalled for a service, additional signalling is provided to alert receivers to the changes. If the activated hard linkage set for the service is changing, a short form service linking FIG is sent which contains two service linking fields; the first carries the details of the hard linkage set being deactivated, the second contains the hard linkage set that is being activated. If the activated soft linkage set for the service is changing, a service linking FIG is sent which contains two service linking fields; the first carries the details of the soft linkage set being deactivated, the second contains the soft linkage set that is being activated. If both the activated hard linkage set and the activated soft linkage set for the service are changing, a service linking FIG is sent which contains four service linking fields; the first carries the details of the hard linkage set being deactivated, the second contains the hard linkage set that is being activated, the third carries the details of the soft linkage set being deactivated, the forth contains the soft linkage set that is being activated. In this way, all changes are signalled in the same FIG ensuring that only one hard and one soft linkage set are activated at any one time. These FIGs are sent once per second for five seconds to enable rapid linking and delinking.

The state of the LA flag shall always be consistent with the activation state of the linkage set.

5.2.5 Receiver behaviour for a link

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the service linkage database entry associated with each key- OE flag, P/D flag, S/H flag, ILS flag, LSN. Some linkage sets may be activated, others deactivated, as indicated by the LA flag for each key. FIG0/6 in the long form carries the lists of identifiers. During this phase, it is necessary to wait for the FIG0/6 in the long form with the C/N flag set to 0 indicating start of database in order to determine the SId(s) in the tuned ensemble to which the linkage set relates, although linkage sets may be built up whenever they are received. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to. There is a limit of 128 Ids (SIds, PI codes, etc) in each linkage set (OE, P/D, S/H, ILS, LSN).

5.2.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/6 in short form with the C/N flag set to 0, receivers are informed that the part of the linkage database corresponding to the database key - OE, P/D, S/H, ILS, LSN - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry for the indicated database key.

5.2.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the linkage information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/6 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the key - OE, P/D, S/H, ILS, LSN. The receiver shall watch for FIG0/6 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the identifiers according to the bearer information indicated by the IdLQ.

NOTE: Care should be taken to recall that when a FIG0/6 is received where the P/D flag is 0, the OE flag is 0 and the C/N flag is 0 that regardless of the IdLQ field, the first identifier is a DAB SId.

5.2.5.3 Reaction to activation and deactivation

Reception of the short form of FIG0/6 with the C/N flag set to 1 provides information on the activation and deactivation of defined linkage sets. Each service can only be in one active hard linkage set and in one active soft linkage set at any one time. The activation state of all linkage sets is transmitted every 10 seconds. When changes to the activation state take place, the activation state of the affected linkage sets is sent more frequently.

The flags OE, P/D, S/H, ILS and the LSN define which database entry is being activated or deactivated and the LA flag indicates the activation status - LA = 0 means deactivated and LA = 1 means activated. The receiver determines the activation status of a linkage set by the last received LA flag. It is the responsibility of the service provider to ensure the LA flag always correctly indicates the activation state.

5.3 OE Services

The FIG0/24 consists of a header field and one or more OE Services fields.

The OE Services fields can take the short form or the long form and this is determined by the state of the Number of EIds field.

The database key for FIG0/24 consists of the OE and P/D flags from the header field and the SId field from the OE Services field.

5.3.1 Short form - Change event indication

The short form has the Number of EIds field equal to 0. It is used for signalling changes to the database entry of the service indicated by the database key. The C/N flag is set to 0.

5.3.2 Long form - Database definition

The long form has the Number of EIds field not equal to 0. It is used to build up the database of EIds that also carry the service indicated in the SId field. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database entry requires an OE Services field with a start of database indicator; depending on the number of EIds there may be one or more OE Services fields with a continuation of database indicator. The order of transmission of the EIds shall be kept constant so that receivers may build confidence in the information they store.

5.3.3 OE Services fields

The P/D flag determines the length of the SId field that corresponds with a service in the tuned ensemble when the OE flag = 0, or in another ensemble when the OE flag = 1. It is most probable that the information will change very infrequently with a network configuration change when a service is added to or withdrawn from an ensemble.

The database key for FIG0/24 consists of the OE and P/D flags from the header field and the SId field.

5.3.4 Signalling

There are different phases to signalling. The database shall be defined (using the long form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.3.4.1 Defining and redefining the database

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database is about to be defined (a redefinition is simply a definition using an existing database key).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form OE Services field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, and SId - defining which part of the database is being changed.

Next, the database definition begins using the long form OE Services field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database entry, these are sent with C/N set to 1. The complete database entry for each key should be transmitted within 10 seconds.

5.3.4.2 Maintaining the database

Once defined, the EIds for each database entry shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information.

5.3.5 Receiver behaviour

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the OE Services database entry associated with each database key- OE flag, P/D flag, SId. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to.

5.3.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/24 in short form with the C/N flag set to 0, receivers are informed that the part of the OE Services database corresponding to the database key - OE, P/D, SId - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry in the database for the indicated database key.

5.3.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the OE Services information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/24 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the database key - OE, P/D, SId. The receiver shall watch for FIG0/24 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the EIds.

5.4 Frequency information

The FIG0/21 consists of a header field and one or more Frequency Information fields.

The Frequency Information fields can take the short form or the long form and this is determined by the state of the Length of Freq list field.

The database key for FIG0/21 consists of the OE and P/D flags from the header field and the RegionId, Id field and R&M fields from the Frequency information field. The P/D flag is always 0 for FIG0/21.

5.4.1 Short form - Change event indication

The short form has the Length of Freq list field equal to 0. It is used for signalling changes to the database content of the service indicated by the RegionId, Id field and R&M fields. The C/N flag is set to 0.

5.4.2 Long form - Database definition

The long form has the Length of Freq list field not equal to 0. It is used to build up the database of frequency information about DAB ensembles, FM-RDS or other services. The C/N flag is used in the database definition mode and the flag indicates the start of the database definition when set to 0 or a continuation of the database definition when set to 1. Every database definition requires a Frequency information field with a start of database indicator; depending on the number of frequencies there may be one or more Frequency information fields with a continuation of database indicator. The order of transmission of the frequencies shall be kept constant so that receivers may build confidence in the information they store.

5.4.3 Frequency information fields

When the OE flag = 0 it indicates that the Frequency information is for the tuned ensemble or for any other bearer which carries identical content to the primary component of a service in the tuned ensemble. When the OE flag = 1 it indicates that the Frequency information is for other ensembles or services on any other bearer that are not carried in the tuned ensemble. It is most probable that the information will change very infrequently with a network configuration change when a service is added to or withdrawn from an ensemble, or introduced or withdrawn on another bearer.

If frequency information is transmitted divided by RegionId (i.e. RegionId $\neq$ 0) then service following may use the received TII information to determine which frequency information is applicable and therefore reduce the number of alternatives to be tested. If RegionId is not interpreted by the receiver then the service following process shall use all the frequency information provided.

The continuity flag shall be set correctly in order to assist receivers with making switching decisions. For DAB frequencies, the continuity flag indicates whether continuous (i.e. uninterrupted) audio output is possible or not when switching frequencies; for other bearers it indicates whether an appropriate time delay has been added to allow seamless, (or near seamless) audio output or not when switching frequencies. For DAB, the continuity flag should only be set when a DAB ensemble is transmitted on several frequencies with co-timed and synchronized signals. Synchronized means that the frame start (null symbol) is sent at precisely the same moment in time, the interleaving is identical and the guard interval is respected on all frequencies. See clause A.1 for a use case of an MFN which uses the continuity flag.

The database key for FIG0/21 consists of the OE and P/D flags from the header field and the RegionId, Id field and R&M fields.

5.4.4 Signalling

There are different phases to signalling. The database shall be defined (using the long form) and may be redefined (changed) using first the CEI (short form) and then the long form. Database changes should be kept to a minimum. Listeners may tune to an ensemble at any time and therefore the database definition shall be repeated continually.

5.4.4.1 Defining and redefining the database

Each definition or redefinition is handled in the same way. First a CEI shall be signalled to inform receivers that a database entry is about to be defined (a redefinition is simply a definition using an existing database key).

The CEI is signalled at least once per second for a period of five seconds. CEI is defined as the short form Frequency Information field with the C/N flag set to 0 and the database key - the OE flag, P/D flag, and RegionId, Id field and R&M - defining which part of the database is being changed.

Next, the database definition begins using the long form Frequency information field. The C/N flag is set to 0 for the start of the database definition and if more FIGs are required to complete the database entry, these are sent with C/N set to 1. The complete database entry for each database key should be transmitted within 10 seconds.

5.4.4.2 Maintaining the database

Once defined, the frequencies for each database entry shall be transmitted in the same order on each repetition, and shall be transmitted every two minutes to maintain the database and allow newly tuned in receivers to acquire the information.

5.4.5 Receiver behaviour

When a receiver initially tunes to a particular ensemble, it shall begin to assemble the Frequency information database entry associated with each database key- OE flag, P/D flag, RegionId, Id field and R&M. The receiver will never know that the database is complete, and receivers should act upon the information in the database whenever it needs to.

5.4.5.1 Reaction to CEI

When the CEI is received, that is a FIG0/21 in short form with the C/N flag set to 0, receivers are informed that the part of the Frequency information database corresponding to the database key - OE, P/D, RegionId, Id field and R&M - is about to be changed or deleted. The database entry corresponding to the database key is deleted (if present) and the receiver makes whatever preparation is needed to begin to build a new database entry for the indicated database key.

5.4.5.2 Reaction to definition

Following a CEI period, a new database entry corresponding to the Frequency information for the database key indicated in the CEI may be sent. Receivers shall begin to assemble the information when they receive a FIG0/21 in the long form with the C/N flag set to 0, indicating the start of the database entry corresponding to the database key - OE, P/D, RegionId, Id field and R&M. The receiver shall watch for FIG0/21 in the long form with the C/N flag set to 1, indicating a continuation of the database entry, and aggregate the information.

5.5 Transmission model

5.5.1 DAB / DAB service following

There is no such thing as a "standard" DAB network. Depending on very many variables, networks will be built that provide the radio services that are needed. Some examples are listed below. In all cases, it is essential that proper allocation of identifiers is made such that there are no conflicts of information within the country.

A DAB service may be carried in an ensemble which is transmitted on different frequencies. In this case, service providers may assist receivers by providing the Frequency Information for the ensemble using FIG0/21. Clause A.1 illustrates this use case.

Another DAB service may be carried on different ensembles. In this case, service providers may assist receivers by providing the EIds of the other ensembles using FIG0/24 and may provide the Frequency Information for each ensemble using FIG0/21. Clause A.2 illustrates this use case.

Another DAB service may have programme splits according to geography available on different ensembles. At some times of the day, all the ensembles carry the same audio, but at other times, the service splits into regional variants. In this case service linking information is provided with FIG0/6 to define the network configurations and activate and deactivate different combinations. The ensembles on which each service variation is carried is provided with FIG0/24 and the frequencies of the ensembles with FIG0/21. Clause A.3 illustrates this case.

Another scenario is that a service is provided in both DAB and DAB+ in the same ensemble and in DAB+ only on another ensemble. The service provider can assist receivers by providing service linking information that connects the SIds, ensemble information and frequency information as above. Clause A.4 illustrates this use case.

A service provider may have several related radio services which sometimes carry the same content but sometimes carry different content. The service provider would like to help his regular listener in one location to find a similar service when in another location, and for this he provides service linking information with soft links using FIG0/6. He may provide additional information to help receivers tune to the related services. Clause A.5 illustrates this case.

5.5.2 DAB / FM-RDS service following

In order to allow receivers to continue to provide a service carried on DAB when moving beyond the digital coverage area, service providers with the same content available from FM-RDS can provide service following information. In the special case that identical content is ALWAYS carried on DAB and FM-RDS and the SId and PI code are identical, then a service provider can chose not to signal any FM-RDS service linking information, relying instead on implicit linking. In this case no service linking information is signalled and the receiver may switch between the DAB and FM-RDS sources as determined by algorithms in the receiver. However, in the general case, FIG0/6 is used to provide the linkage between the DAB SId and the corresponding FM-RDS PI code or codes. Implicit linking cannot cope with the cases where the content on DAB and FM-RDS is not identical at certain times of day - for this case FIG0/6 can be used to define the linkage set that connects the DAB SId and the RDS PI code together, and the linkage actuator can be used for the dynamic activation and deactivation of the link.

Because the coverage of DAB and FM transmissions may be different, and service providers may localise or regionalise their content on one or both bearers, the relationship between services carrying identical audio content may vary during the day. Each possible combination of DAB SId and RDS PI codes is expressed by a linkage set and as the day progresses and the different combinations become valid, the LA of each linkage set is either activated or deactivated. In this way, the database entries remain constant, but the active alternative services are dynamically controlled.

There are very many possible combinations.

There may be situations where allocation of SIds and PI codes has not been coordinated and service providers with no FM-RDS services may find receivers that implement implicit linkage switch listeners from DAB to the wrong FM-RDS service. To prevent this condition, service providers may signal an FM-RDS link without any PI codes - this is referred to as a "dead link" and is illustrated in annex A.8. If the tuned service is in an active linkage set that includes an Id list of type IdLQ == 01 (RDS PI codes) then implicit linking to the FM service with PI code = SId is disabled. If the service provider wishes to link to a PI code which is the same as the SId and other PI codes, they shall include all PI codes in the Id list.

5.6 Receiver Reference Model

This clause describes a conceptual model of a receiver that implements service following according to these Rules of Implementation.

The purpose of the model is not to specify a particular receiver implementation, but rather to define the expected behaviour of a conformant receiver. It is expected that real receivers may differ from the reference model in their detailed design and implementation, but that they will exhibit the same user-visible behaviour as the model.

A broadcast receiver designed for mobile reception may implement a service following process to keep track of a changing broadcast signal environment. The service following process is determined by 3 design elements.

- Reception monitoring.
- Information base.
- Service following process.

The present document makes assumptions on key aspects of these design elements as described in the following clauses.

Conceptually the receiver consists of a control circuit that monitors the reception quality and selects another service using the information base to recover from a degradation or loss of signal. The service following process is designed such that it provides for the best possible user experience requiring least user intervention along a given travel route.

5.6.1 Reception Monitoring

A mobile receiver shall provide a means to monitor the received signal. This may include one or more aspects of signal reception, such as signal strength, carrier-to-noise ratio, bit-error rates, etc. For each quality indicator a threshold level allows detection of a reduction or loss of signal. The decision circuit may include hysteresis for the ON/OFF decision making.

5.6.2 Information base

To identify a suitable alternative service or frequency resource, a mobile receiver can make use of various information sources. These may include service following information received through the FIC, learning memory and pre-stored data to build the information base. The information base consists of information elements combining frequency information, service identifiers and ensemble identifiers to unambiguously identify a broadcast signal. Since LSNs are allocated on a national basis, it is necessary to store the country code from the ensemble identifier along with the LSNs (and ideally the ECC too if available) in order to eliminate errors in the information base in areas where ensembles from more than one country are receivable.

The present document discusses solely information provided via the FIC forming the service following information. This may take some time to acquire and thus receivers benefit from storing in memory relevant service following information. It is assumed that the service following information represents the dominant part of the information base.

5.6.3 Service Following Process

5.6.3.1 Overview

The service following process deploys a multi-stage algorithm to keep track of a selected service and signal and where this fails, to identify and select a alternative signal and/or service. The service following process is an automated routine controlling tuning and decoding units to maintain and (re-) establish a minimal service reception.

When a loss of signal is detected, the service following process starts to test each element in the information base for signal and service availability. The service following process continues until service reception is re-established or a user intervention occurs. The process should prioritise a DAB service such that it is always selected while available.

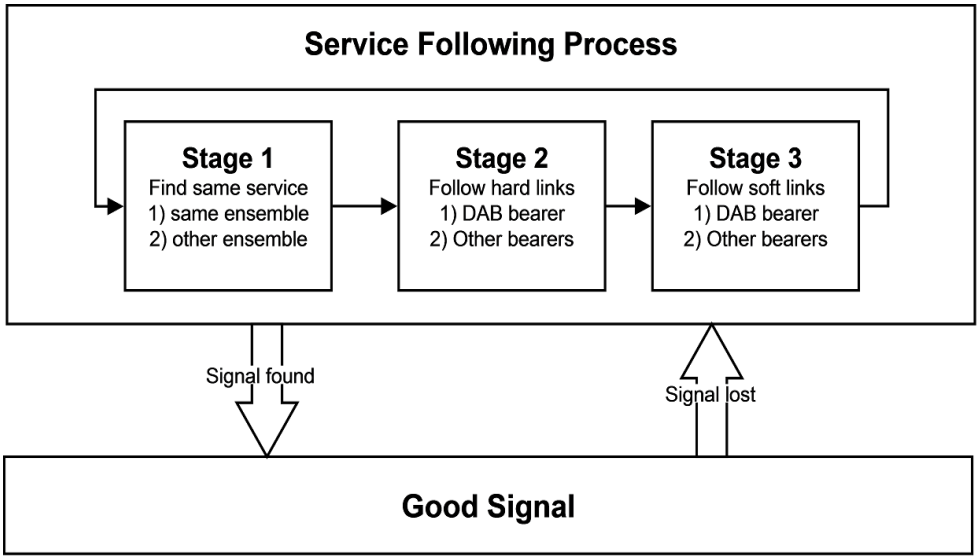

Figure 2: Service following process flow diagram

The service following process takes three stages, each stage is executed if the previous stage fails.

Stage 1 tries to recover the selected service 'as selected', testing only information elements that identify 'exactly the same' service at another frequency. The receiver should only change to services having the same service Id, as the user selected service. This should prioritise frequencies that transmit the same ensemble as the user selected.

Stage 2 searches for hard linked services as given in the information base. The receiver tries to identify services that are hard-linked with the selected service on either the DAB bearer or other bearers. This will allow a change of service, but will present the same audio content.

Stage 3 performs a search for soft-linked services on available bearers. 'Soft linked' services may represent various logical relationships to the reference service and may require user intervention to select. As in Stage 2, DAB-system service alternatives should be prioritised and other bearers should be evaluated secondly.

The Service Following Process has a cyclic design to account for the receiver moving randomly within the signal coverage, where no assumptions on signal availability can be made. The process always starts at stage 1, when the user selected service is not available. This may happen following a user action such as a preset call, or when a mobile receiver has moved out of the reception coverage area.

Subsequently the receiver will try to find a broadcast signal that contains the user selected service or, if this fails, a suitable alternative according to the service following information. The process ends, if a suitable service can be presented to the user. If in the course of this process, the receiver has tuned to a bearer other than the DAB system, it is expected to return to a DAB system service with priority.

It shall be noted here that a prioritisation of DAB system reception will cause the receiver to return to a DAB system signal as soon such signal can be recovered. This may occur independently of the signal availability on other bearers.

This description provides only a rough outline of a factually implemented service following process. Any optimisations are implementation specific.

5.6.3.2 Stage 1: Find same service

The service following process begins at stage 1. This may happen, when the user selects the service that they wish to listen to, for example by pressing a preset button or by selecting a service from a list on the receiver's display.

The stored DAB SId of the selected service represents the Target SId. In this stage, the receiver attempts to locate a DAB ensemble containing a service with SId equal to the Target SId.

It may use Multiplex Configuration Information and Other Ensemble Service Information and observed information from previously-tuned ensembles to determine a list of candidate ensembles. From that list the receiver attempts to identify an ensemble that carries the target SId.

The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. For example, different receiver implementations may make different trade-offs between maximising the initial reception quality and minimising the initial selection time. Similarly, different receiver implementations may have different resources available (e.g. number of tuners, processing power, storage) that influence such trade-offs.

Note that information from previously-tuned ensembles may be incomplete or out-of-date and that previously-tuned ensembles may or may not be receivable at the current location. Different receiver implementations may use different strategies for determining how much information to store and when to refresh it. For example, a single-tuner receiver performing a service following decision may make a first quick pass using cached information and then perform another slower pass during which all information is refreshed, whereas a dual-tuner receiver with sufficient storage may cache all information and operate continuously in the background. Similar considerations apply to the following stages, with the difference that the target Sid represents a different service that has a linkage relationship to the selected service.

5.6.3.3 Stage 2: Follow hard links

At this stage, the receiver has failed to select the Target SId on any DAB ensemble. The receiver next attempts to find a service that is hard-linked to the Target SId and is therefore carrying identical audio content to the Target SId.

Stage 2.1

The receiver uses linkage information received for the selected service to assemble a list of target DAB SIds. From that list the receiver attempts to identify ensembles and frequencies that carry a linked SId. The receiver uses broadcast provided and observed information for this task. The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. Finally it will select an available service according that order.

Stage 2.2

The receiver uses Linkage Information from previously-tuned ensembles to determine a list of candidate services on FM-RDS or other bearers that may be hard-linked to the Target SId.

This includes implicitly linked RDS services.

Then the receiver uses Frequency Information from previously-tuned ensembles and observed information from previously-tuned frequencies to determine a list of candidate frequencies for each candidate linked service.

From that list, the receiver attempts to select each candidate service on each candidate frequency in turn.

The receiver may use any available quality information and any criteria it chooses to filter or determine the priority order of candidates. Finally it will select an available service according that order.

5.6.3.4 Stage 3: Follow soft links

At this stage, the receiver has failed to select the Target SId on any DAB ensemble and has also failed to select an equivalent hard-linked service on DAB or other bearers. The receiver next attempts to find a service that is soft-linked to the Target SId. This means a service with the same audio content is not available and a related service may represent the best alternative service according to the users expectations. A related service may be a regional variant of the selected service, it may be a language variant, a similar service on another network or another service within the same network.

Stage 3.1 and 3.2 are identical to stage 2.1 and 2.2 respectively, with the exception that stage 3 uses soft-linked services where stage 2 uses hard-linked service identifiers. As soft-linked services have generally different audio content, the receiver needs to avoid confusion over a possible change of service. Therefore soft-links should generally not be activated in a fully automated manner, this may require user interaction upon activation.

5.6.3.5 Handling of bearer system transitions

The service following process is designed to present the best available alternative to the user selected service. In the course of this process the alternative service may represent a significant departure from the initial user selection. The process shall be designed in a way that the receiver respects the initially user selected service at all times.

In the case of a bearer transition the receiver has moved away from the DAB system and is receiving a service on another bearer system, e.g. FM-RDS. If service following rules on the other bearer system are inconsistent with the rules applicable to DAB, it is left to the discretion of the implementer how conflicts or ambiguities are best handled in the interest of the user.

For example on FM-RDS a service may be regionalised. The user selected DAB service may only be linked to a particular regional variant of that service. Within the FM-RDS, a receiver may select another regional variant as part of the service following. As regionalisation does not exist on DAB, returning to DAB on the other regional variant would represent a change of service and could conflict with the user expectation.

E.g. the user has selected SId = 0xD311, by implicit linkage the receiver selects PI code = 0xD311 as the DAB signal is lost. During a regional broadcast the tuned service changes to PI code = 0xD411. The implicit link would allow the receiver to return to SId = 0xD411, but this could represent a change of service and could conflict with the user expectation or the broadcasters intention. It is recommendable to require an explicit link being signalled on DAB to allow the change from PI code = 0xD411 to SId = 0xD411.

A similar situation may occur, when linkage information is temporally dynamic. After having followed a link, the receiver should ensure the validity of the linkage information. It may restart the service following process, if the currently selected service does not represent a valid alternative of the user selected service any more, e.g. if changes of the linkage information on DAB have occurred.

5.6.4 Stored services ("presets")

If the user stores a service as a preset on the receiver, and the service is not found when the user subsequently selects the preset, the receiver shall attempt all service discovery and linking methods to locate that service, or an alternative service advertising the preset service as a link.

Since relevant linkage information may not be available on the current ensemble, when a service is selected from memory, the receiver may store available linkage information related to the selected service at the time the service is stored.

EXAMPLE: A Service is stored on a preset with SId = 0xC586, EId = 0xC181, ECC = 0xE0, F = 227 360 kHz.

The user moves to a different location, and recalls the preset.

The receiver attempts to locate ensemble EId= 0xC181, ECC = 0xE0 at F = 227 360 kHz, and fails.

The receiver should then attempt to discover SId = 0xC586 on alternative ensembles/frequencies. If that fails, the receiver should examine Linkage Sets (either acquired or stored) to locate SId = 0xC586 as a destination.

The receiver finds a linkage set with service SId = 0xC386 as the originating service, hard linked to 0xC486, 0xC586, 0xC686, 0xC786. As 0xC586 exists in this list, any of the services in this list (0xC386, 0xC486, 0xC686, 0xC786) are acceptable alternatives.

The receiver has recently acquired SId = 0xC686, EId = 0xC194, ECC = 0xE0 at F = 218 640 kHz, and therefore tunes to this service as an acceptable alternative.

This behaviour is necessary to emulate the behaviour of recalling an FM preset when REG PI code following is enabled.

5.6.5 Linkage sets

The receiver maintains a number of Linkage Sets as part of an information base used for Service Following decisions.

Each Linkage Set contains the Identifiers for a set of one or more services, possibly on different bearers, that are equivalent (hard linked) or related (soft linked).

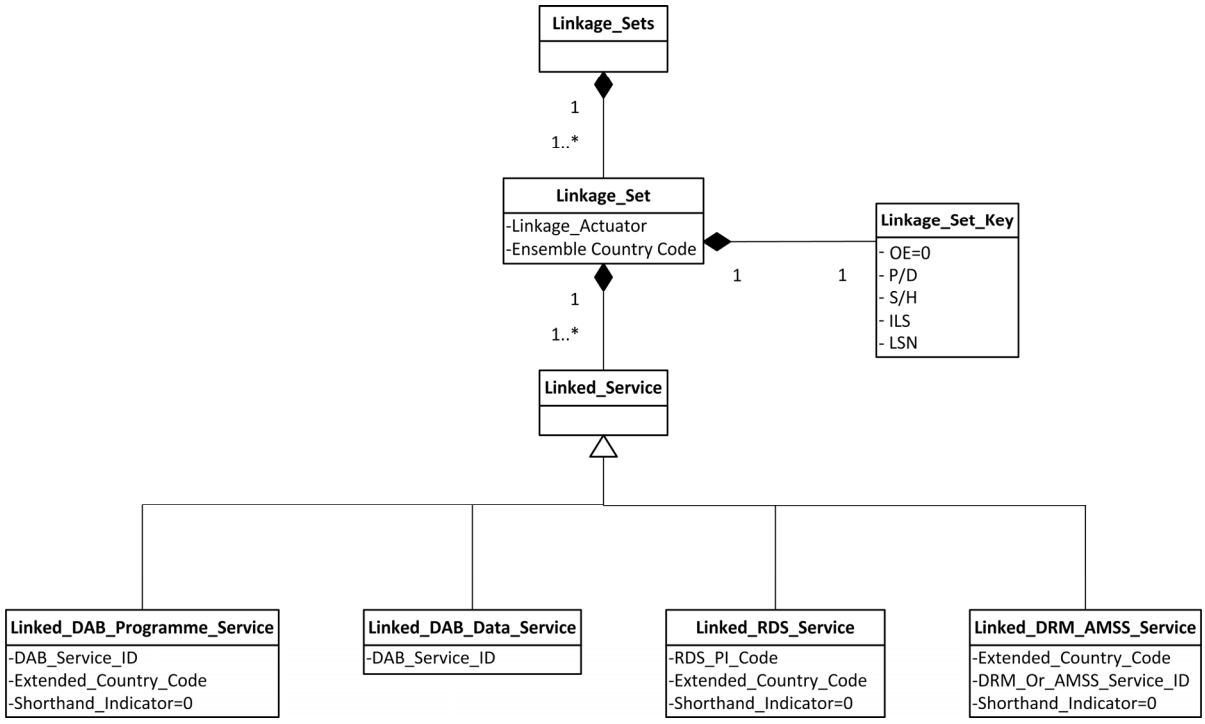

Figure 3: Structure of linkage sets

Each linkage set is uniquely identified by a database key comprising the Programme/Data flag, Other Ensemble flag, Soft/Hard flag, International Linkage Set flag, and Linkage Set Number.

Each linkage set contains one or more services which carry the same (in the case of hard links) or related (in the case of soft links) content.

Each service in a Linkage Set may be either a DAB Programme service, a DAB Data service, an FM-RDS service, a DRM service or an AMSS service.

Depending on its type, each service contains the information required to identify the corresponding service on its respective bearer; for example a DAB Service Id or RDS PI Code, and optionally, an Extended Country Code.

Any service can only be active in one hard linkage set and active in one soft linkage set at a time. A service can only be active in either a national linkage set or an international linkage set at a time.

If a receiver detects a conflict, and a service becomes active in more than one linkage set, the receiver may inactivate all linkage sets cached on the receiver containing that service, identified by the SId. Receivers are not required to detect conflicts and broadcasters shall not depend on them doing so.

5.6.6 Linkage set management

The receiver obtains the linkage sets from information supplied by service providers and signalled in FIG0/6.

Figure 4 defines the process by which a receiver may obtain and manage all of the linkage sets transmitted on the current ensemble.

Figure 4: FIG0/6 process tree

Receiver implementations may differ in the number of linkage sets they can store at any one time. As a minimum, a basic receiver shall maintain the currently active linkage set for the currently selected audio programme service. A more advanced receiver with additional storage capacity may maintain additional linkage sets - for example those associated with services stored on presets or otherwise determined to be of interest to the user.

A receiver implementation need only store the identifiers for bearers that it is capable of receiving and intends to use for service following. For example, a receiver that does not support service following from DAB to DRM need not store any DRM service identifiers in the linkage sets.

Annex A (informative): Service following use cases

A.1 DAB to DAB link in Multi-Frequency Networks

A.1.1 Problem Description

The same ensemble is transmitted on channel 5A and channel 5C (174 928 kHz and 178 352 kHz). Both areas are adjacent. The transmission mode is I. The signals are co-timed and synchronised.

Users may expect almost seamless switching between the different frequencies when the ensembles are identical and synchronized.

Synchronized means that the frame start (Null symbol) is sent at precisely the same moment in time, the interleaving is identical and the guard interval is respected. A synchronized MFN is managed like an SFN, the only difference being that the signal is modulated on more than one frequency.

A.1.2 Concept

A dual tuner device will find the alternative by scanning in the background.

A single tuner/decoder device should try to monitor the signal strength at all the frequencies indicated by the frequency information in FIG0/21. If a signal is available on another frequency it might try to retune the tuner while keeping the decoder pipeline in operation. Confirming the EId of the chosen frequency before switching reception of the MSC should provide for seamless switching.

A.1.3 Signalling

A.1.3.1 FIG0/6 Service linking information

Not required for this use case.

A.1.3.2 FIG0/24 OE Services

Not required for this use case.

A.1.3.3 FIG0/21 Frequency Information

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned Ensemble
P/D	0	not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	9	Length in bytes of the following FI list
Id field (Identifier field)	0xD201	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	1	The ensemble is co-timed and synchronised
Length of Freq. list	6	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x02AB5	The multiplier of 16 kHz of the centre frequency 174 928 kHz
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x02B8B	The multiplier of 16 kHz of the centre frequency 178 352 kHz

A.1.4 Receiver Behaviour

A.1.4.1 Single tuner device

A single tuner decoder device should try to monitor the signal strength of the frequency it is not tuned to; so when tuned to 5A it should monitor the signal strength of 5C and vice-versa. If the receiver can also determine the EId of the signal at the other frequency it can confirm if the correct ensemble is present.

If the signal strength on the other frequency is better it should retune while keeping the decoder pipeline in operation.

If the EId of the newly acquired ensemble does not match the original then the receiver should retune to the original frequency.

A.1.4.2 Dual tuner device

A dual tuner will synchronise the second tuner to the second frequency. In case of signal loss on the first frequency he might switch the tuner or retune the foreground tuner keeping the decoder pipeline in operation.

A.2 Linking to the same service on different ensembles

A.2.1 Problem Description

The same programme service (same SId) is available on multiple ensembles (differing EIds), and those ensembles are on a variety of frequencies.

The following example represents a case in Switzerland in 2011.

Figure A.1 illustrates the coverage areas of three different ensembles. The example explains service following for one service that is available in all ensembles. The bold line illustrates a possible travelling route between the different coverage areas.

The ensemble with EId 0x4001 is geographically adjacent to the ensemble with EId 0x4041 and some areas have coverage from both ensembles, for example, when travelling from point A to point B. The ensemble with EId 0x4081 is surrounded by high mountains and has no overlapping coverage areas with any of the other ensembles. This region can only be reached via tunnels or passes. So travelling from any of the other ensembles to the coverage area of ensemble 0x4081 will result in lost DAB reception.

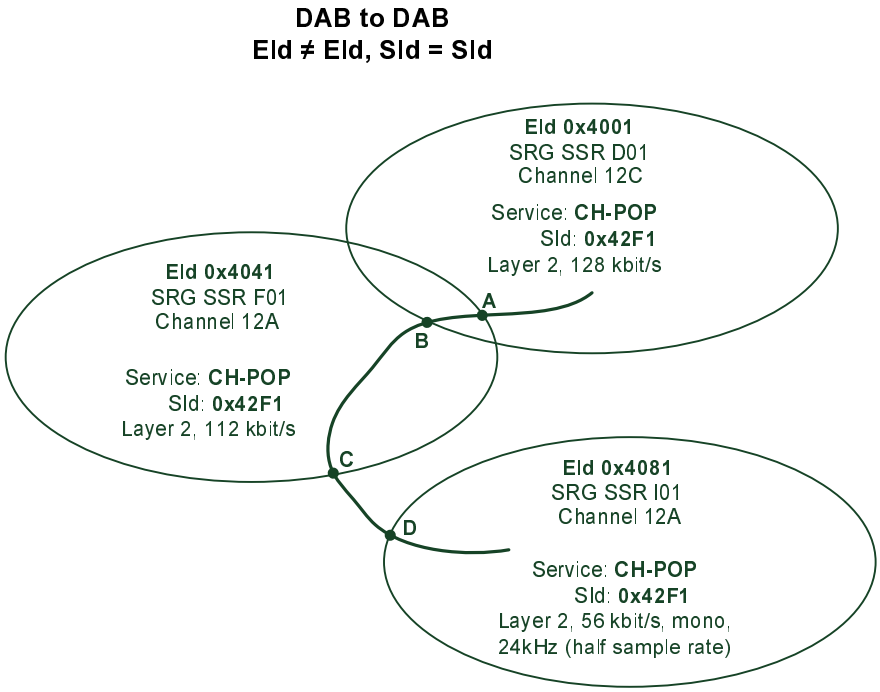

Figure A.1: Ensemble coverage schematic

A.2.2 Concept

Signalling of FIG0/24 will help a single tuner to identify alternative ensembles carrying the same service.

Signalling of FIG0/21 will help a single tuner to find the frequencies of the alternative ensembles.

A dual tuner may detect the same service on a different ensemble and frequency by periodic analysis of received signals.

A.2.3 Signalling

A.2.3.1 FIG0/6 Service linking information

Not required for this use case.

A.2.3.2 FIG0/24 OE Services

Signalled in all ensembles, EIds in the same order.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble (the service exists in the tuned Ensemble)
P/D	0	Programme service
SId	0x42F1	Service for which ensemble information is being signalled
Rfa	0	
CAId	0	No Conditional Access applicable
Number of EIds	3	3 Ensemble Ids to follow
Ensemble Identifier	0x4001	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4041	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4081	Ensemble Id of an ensemble carrying the Service

A.2.3.3 FIG0/21 Frequency Information

Signalled *differently* in each ensemble since this is the OE frequency information. Signalled in Ensemble **0x4001** as below.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	12	Length in bytes of the following FI list
Id field (Identifier field)	0x4041	EId of the other ensemble
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x4081	EId of the other ensemble
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Not adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz

A.2.4 Receiver Behaviour

A receiver should decide a point at which the currently received signal is inadequate. For a single tuner device this may be through use of a fixed reference point, and for a dual tuner by comparison with the quality of signal being received from other frequencies.

The receiver should attempt to locate the current service on an alternative ensemble. It may use the OE services and frequency information provided by the broadcaster, using Region Information when supplied to reduce the number of alternative ensembles to try to just those in the current Region.

If this fails, or no OE services information is being signalled, the receiver will attempt to locate the current service by scanning all possible frequencies and analysing all the services on the ensembles found.

E.g. travelling from point A to C in the picture above. Between A and B, both Ensembles are available and in both Ensembles FIG0/24 and FIG0/21 are signalled. Switching between the Ensembles may occur at any time.

A.3 Linking regional variations of a service on different ensembles

A.3.1 Problem Description

A programme service is broadcast across multiple regions, on different ensembles. At certain times the programme service is identical on all ensembles, and at other times the content is different. As the programme content is not always identical on all ensembles at all times, each regional variation has a different SId code. The periods of non-identical content may be of only a few minutes duration, such as commercial breaks or news bulletins, or may be for the duration of a programme segment.

At times when the programme service is identical, the broadcaster wants the listener to experience continuous coverage, as if the service was transmitted with the same SId code on all ensembles.

At times when the programme service is not identical, the broadcaster does not want the listener to be switched between regions automatically by the receiver.

The broadcaster can control whether linking is active or inactive, and can do so quickly and often.

In figure A.2 the four related services are carried on four ensembles. On weekdays the following schedule applies: from midnight until 06:00, the four services carry the same audio; from 06:00 until 10:00, the four services are all separate; from 10:00 until 16:00 the four services again have identical audio; from 16:00 until 19:00 the two services in the west share one programme and the two services in the east share a different programme; from 19:00 until midnight all four services are again identical. On Saturday schedule has all four services carrying the same audio except between 14:30 and 17:00 when the two services in the north carry one football match, whilst the two services in the south each carry their own football match. On Sundays, all services carry the same audio.

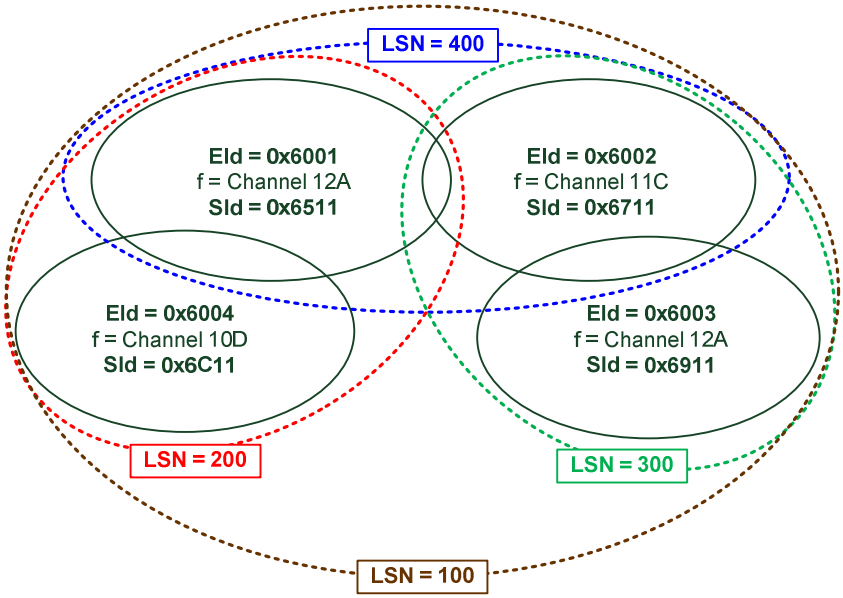

Figure A.2: Service and ensemble configuration

A.3.2 Concept

There are four network configurations with services that need to be linked and each is represented by a linkage set. The linkage sets are signalled in each ensemble that has a service that is linked, so all ensembles include the linkage set for all four services linked together and the two western ensembles also have the linkage set for the two western services linked whilst the two eastern ensembles also have the linkage set for the two eastern services linked. In addition, the two northern ensembles have the linkage set for the two northern services linked. FIG0/6 in the long form is used to repeat these definitions throughout the day. According to the time of day, the appropriate linkage set is activated or deactivated using FIG0/6 in the short form.

To assist single tuner devices, the OE Services (FIG0/24) and frequency information (FIG0/21) may be signalled. OE Services links the SId and EId and frequency information provides the centre frequency of the ensembles.

A dual tuner may detect the linked services on other ensembles by periodic analysis of received signals.

A.3.3 Signalling

A.3.3.1 FIG0/6 Service linking information

The information describing the linkage set for all services linked together (LSN = 100) is signalled on all four ensembles and the order of the SId list is the same on all four. The information describing the linkage set when the western services are linked together (LSN = 200) is signalled on the two western ensembles; again the order of the SId list is the same on both ensembles. Similarly, for the eastern (LSN = 300) and northern (LSN = 400) linkage sets. Therefore each ensemble will signal three linkage sets at all times. The state of the link actuators will always be set in accordance with the linkage schedule both in the slower cyclic repetition of the long form database definition FIGs and the faster cyclic repetition of the short form activation state FIGs. When the activation states change then a burst of short form FIGs are sent.

The following information is sent on ensemble 0x6001; the linkage actuator settings are according to the time of day. This snapshot was taken at 18:00 on a Wednesday when the "western" linkage set is activated.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6711	SId of service
Id3	0x6911	SId of service
Id4	0x6C11	SId of service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6C11	SId of service
Id List Flag	1	Long form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x6511	SId of service
Id2	0x6711	SId of service

The activation state of all the linkage sets in the ensemble is sent regularly. Some examples are given below, again for a Wednesday.

At 05:07, 11:13, 14:58, 20:03; 23:45, the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 06:27, 07:53, 09:59 the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 16:00, 17:13, 18:54 the following information was sent.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	Western linkage set
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x400	Northern linkage set

At 19:00:00 the network configuration changes from the western services being linked to all services being linked. The following change information was sent in a short burst.

Field	Value	Description
C/N	1	Continuation of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	0	Short form
Linkage Actuator	0	Linkage set is deactivated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x200	All services linkage set
Id List Flag	0	Short form
Linkage Actuator	1	Linkage set is activated
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x100	Western linkage set
NOTE: The deactivated linkage set is signalled first, the activated linkage set is signalled second.		

A.3.3.2 FIG0/24 OE Services

The information describing the OE Services is signalled on each of the four ensembles for the three related services. The information is different on each ensemble because each has a different set of three other ensemble services.

The following information is sent on ensemble 0x6001.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x6711	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6002	Ensemble Id of an ensemble carrying the Service
SId	0x6911	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6003	Ensemble Id of an ensemble carrying the Service
SId	0x6C11	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x6004	Ensemble Id of an ensemble carrying the Service

A.3.3.3 FIG0/21 Frequency Information

The information describing the Frequency information is signalled on each of the four ensembles for the three related ensembles. The information is different on each ensemble because each has a different set of three other ensembles.

The following information is sent on ensemble 0x6001.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	18	Length in bytes of the following FI list
Id field (Identifier field)	0x6002	EId
R&M	0b0000	Range and Modulation, DAB ensemble
Continuity flag	0	The ensemble is not co-timed and synchronised
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x035CC	The multiplier of 16 kHz of the centre frequency 220 352 kHz
Id field (Identifier field)	0x6003	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	0	The ensemble is not co-timed and synchronised
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Non-adjacent area, transmission mode I
Freq	0x036AC	The multiplier of 16 kHz of the centre frequency 223 936 kHz
Id field (Identifier field)	0x6004	EId
R&M	0b0000	Range and Modulation, DAB ensemble.
Continuity flag	0	The ensemble is not co-timed and synchronised
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Adjacent area, transmission mode I
Freq	0x03482	The multiplier of 16 kHz of the centre frequency 215 072 kHz

A.3.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.

In each linkage set where the current SId is present in the Id list, and where the linkage set is activated (LA = 1), there is a list of alternative SId codes for the current service.

In conjunction with OE Services (FIG0/24) and Frequency information (FIG0/21) (where provided), the receiver should try the alternative SId codes in any sequence to locate the alternative service on a different ensemble, and with an acceptable signal quality.

The receiver should minimise the time taken to locate the alternative service.

If the receiver has current knowledge of which alternative ensembles and services can be received, for instance by using a dual tuner, then it should switch immediately to the alternative service with the best signal quality.

If ensemble information and frequency information is provided for the alternative services, then this should be used to initially try only frequencies where one or more ensembles carrying the alternative services may be received. In this case, multiple alternative services on multiple alternative ensembles may be checked on a fewer number of frequencies.

If an alternative service cannot be found on the ensembles and frequencies provided in FIG0/24 and FIG0/21, the receiver tries all possible frequencies to locate an alternative service.

On locating an alternative service, and concluding that the signal quality is better than the current service and all other alternatives, the receiver switches automatically and without user intervention.

After switching to the alternative service on a different ensemble, the receiver uses service linking information received from the new ensemble for further linking.

A.4 Linking technology variations of a service on different ensembles

A.4.1 Problem Description

The very same audio content may be distributed in different ensembles (different EId) with a different SId because on some ensembles the audio is coded as MPEG layer 2 (DAB), whilst on other ensembles the audio is coded as AAC (DAB+). Those ensembles may or may not have overlapping coverage areas.

The following example represents a case in Switzerland in 2011.

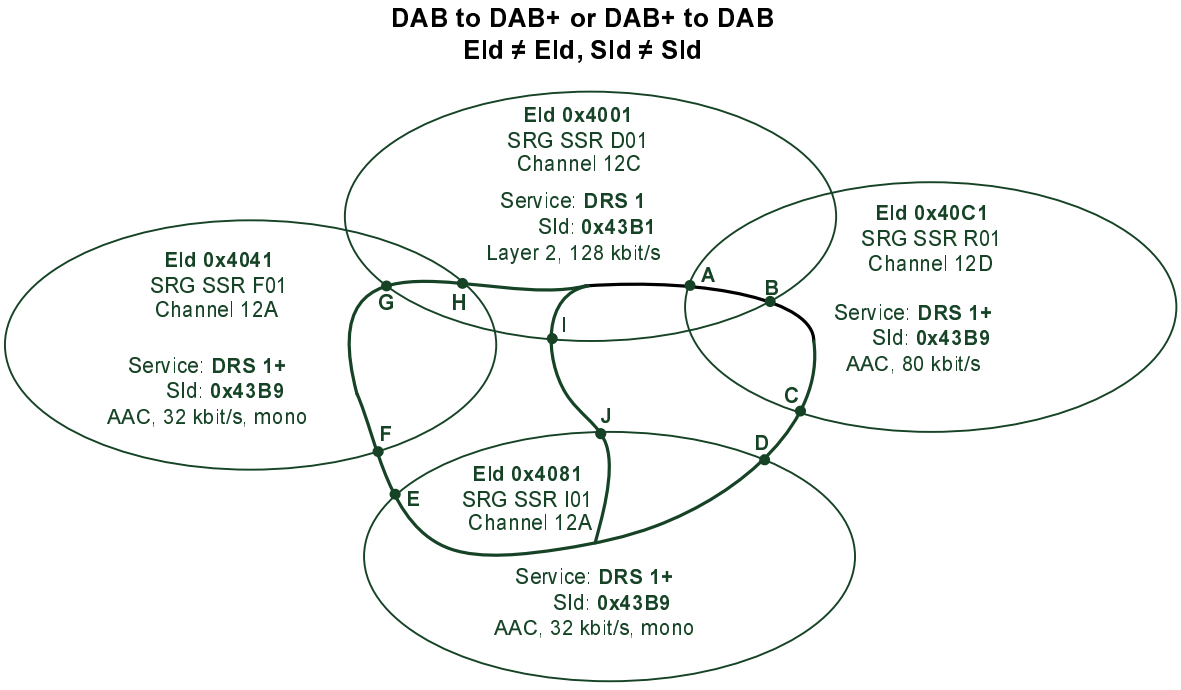

Figure A.3: Ensemble coverage schematic

A.4.2 Concept

Signalling of FIG0/6 in both/all ensembles is be provided to link those services together.

Signalling of FIG0/21 will help a single tuner device to find the alternative frequency.

Signalling of FIG0/24 will help a single tuner to identify the ensemble carrying the linked service.

A dual tuner device may find the alternative frequency by scanning all frequencies in the background.

A dual tuner may also detect the linked service in one of the scanned frequencies.

A.4.3 Signalling

A.4.3.1 FIG0/6 Service linking information

The same signalling is provided in all ensembles.

Field	Value	Description
C/N	0	Start of database
OE	0	Tuned ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Link is always active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x3B1	Linkage Set Number
Rfu	0	1 bit reserved for future use
IdLQ	0b00	Each Id represents a DAB SId (2 bit)
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of SIds in the list
Id1	0x43B1	SId
Id2	0x43B9	SId

A.4.3.2 FIG0/24 OE Services

In ensemble **0x4001**

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x43B9	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	3	Number of Ensemble Ids to follow
Ensemble Identifier	0x4041	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x4081	Ensemble Id of an ensemble carrying the Service
Ensemble Identifier	0x40C1	Ensemble Id of an ensemble carrying the Service

In the other ensembles

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the service is carried in other ensembles)
P/D	0	Programme service
SId	0x43B1	Service for which ensemble information is being signalled
Rfa	0	1 bit reserved for future additions
CAId	0	No Conditional Access applicable
Number of EIds	1	Number of Ensemble Ids to follow
Ensemble Identifier	0x4001	Ensemble Id of an ensemble carrying the service

A.4.3.3 FIG0/21 Frequency Information

In Ensemble **0x4001**

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used for Frequency Information
RegionId	0b000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	18	Length in bytes of the following FI list
Id field (Identifier field)	0x4041	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Geographically adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x4081	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00011	Geographically not adjacent area, transmission mode 1
Freq	0x036AC	223 936 kHz
Id field (Identifier field)	0x40C1	EId of the other ensemble
R&M	0b0000	DAB ensemble
Continuity flag	0	Continuous audio output not expected
Length of Freq. list	3	Length in bytes of the following Freq list
Control field	0b00010	Geographically adjacent area, transmission mode 1
Freq	0x037ED	229 072 kHz

In each of the other three ensembles, the frequencies of the ensembles will be provided in the same way. The order of the frequencies in the list(s) does not have a meaning.

A.4.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.

In each Linkage Set where the current SId is present in the Id list, and where the link set is active (LA = 1), there is a list of alternative SId codes for the current service.

In conjunction with OE Services (FIG0/24) and frequency information (FIG0/21) (where provided), the receiver should try the alternative SId code to locate the alternative service on a different ensemble, and with an acceptable signal quality.

E.g. travelling from point A to C in the picture above. Between A and B, two ensembles are available and in both ensembles FIG0/24 and FIG0/21 are signalled. Switching between the ensembles may occur at any time.

The receiver should minimise the time taken to locate the alternative service.

If the receiver has current knowledge of which alternative ensembles and services can be received, for instance by using a dual tuner, then it should switch immediately to the alternative service with the best signal quality.

If OE Services and frequency information is provided for the alternative services, then this should be used to initially try only frequencies where one or more ensembles carrying the alternative services may be received. In this case, multiple alternative services on multiple alternative ensembles may be checked on a fewer number of frequencies.

On locating an alternative service, and concluding that the signal quality is better than the current service and all other alternatives, the receiver switches automatically and without user intervention.

If an alternative service cannot be found on the ensembles and frequencies provided in FIG0/24 and FIG0/21, the receiver tries all possible frequencies to locate an alternative service.

If travelling from B to D in the example above, crossing an uncovered area, the receiver starts scanning at point C but the last received FIG0/6, FIG0/24 and FIG0/21 remain in the memory and is used when entering the other ensemble at point D.

After switching to the alternative service on a different ensemble, the receiver uses service linking information receiver from the new ensemble for further linking.

A.5 Soft linking of services

A.5.1 Problem Description

The broadcaster with a number of regional variations of a programme service illustrated in clause A.3 also wishes to indicate to his listeners when a *related* service is available during the times when the services are *not* hard linked together. He may do this by creating a linkage set that includes all his DAB services and his services on other bearers too, like FM-RDS, and signalling this as a *soft* link.

At certain times, some of the regional variations carry identical content, and are linked together using hard links, whilst others are either carrying exclusive content or linked to other regional variants. The regional variants with identical content will be present and active in one hard linkage set, but they may also be active in one soft linkage set at the same time. Therefore, when a receiver cannot find any alternative hard linked services, it may offer the listener a soft linked service that is available.

Figure A.4 illustrates the DAB services available from the example in clause A.3 and also adds the FM-RDS services. Note that LSN = 100 has again been chosen to represent the set of all services, but this is distinguishable from the linkage set in clause A.3 because of the associated Soft/Hard flag.

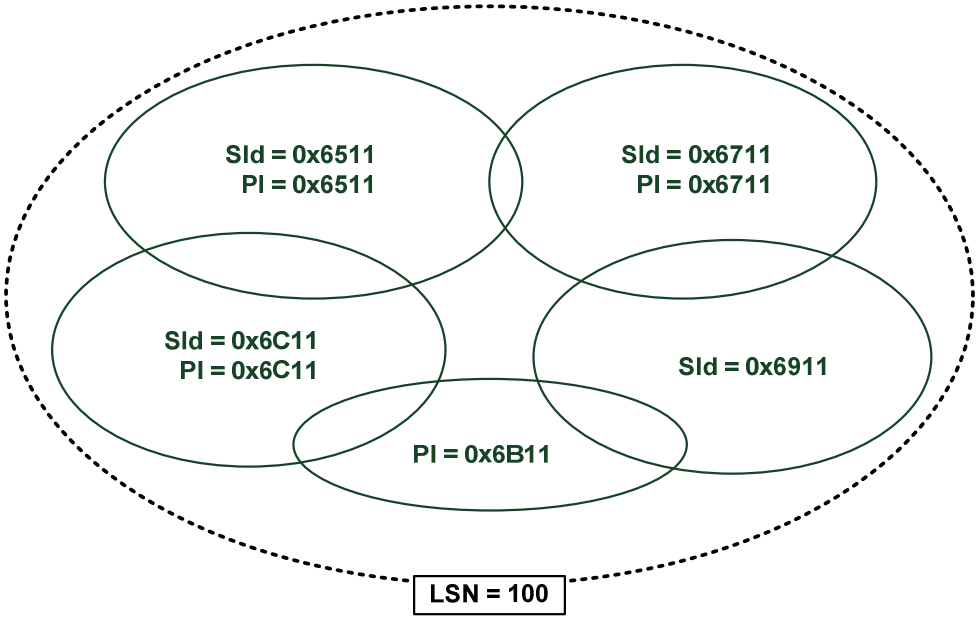

Figure A.4: Service configuration

A.5.2 Concept

All the regional variations of the programme service are contained in a single Linkage Set, with the S/H flag set to 0, indicating a soft linkage set. Some or all of the regional variations may also be in hard linkage sets, which are activated only when the programme content is identical.

The linkage set is transmitted by all the ensembles carrying the regional variations, and the order of the identifiers of the linkage set will be identical on all ensembles. The soft linkage set is always active.

To assist single tuner devices, the OE Services (FIG0/24) and frequency information (FIG0/21) may be signalled. OE Services connects the SId and EId and frequency information provides the centre frequency of the ensembles and the frequency of the FM-RDS services.

A dual tuner may detect the linked services on other ensembles by periodic analysis of received signals.

A.5.3 Signalling

A.5.3.1 FIG0/6 Service linking information

The FIG0/6 information describes all the similar regional variations of the programme service, both carried on DAB and FM-RDS. Each ensemble signals this linkage set at all times. Note that the same LSN is used in this example for the soft and hard linkage sets that represent all the services, but that these linkage sets are distinct because the one in clause A.3 is a hard linkage set and the one in this annex is a soft linkage set. However, different LSNs could also have been allocated.

Since the soft linkage set is always active no change FIGs will be sent. However, the linkage information will be sent every two minutes and the state of the linkage actuator will sent every 10 seconds.

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	0	Soft link
ILS	0	National link
LSN	0x100	Linkage Set Number for all regional variants
IdLQ	0b00	Each Id represents a DAB SId
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of Ids in the list
Id1	0x6511	SId of Service
Id2	0x6711	SId of Service
Id3	0x6911	SId of Service
Id4	0x6C11	SIf of Service

Field	Value	Description
C/N	1	Continuation of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	0	Soft link
ILS	0	National link
LSN	0x100	Linkage Set Number for all regional variants
IdLQ	0b01	Each Id represents an FM-RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	4	Number of Ids in the list
Id1	0x6511	PI code of Service
Id2	0x6711	PI code of Service
Id3	0x6B11	PI code of Service
Id4	0x6C11	PI code of Service

A.5.3.2 FIG0/24 OE Services

See clause A.3.

A.5.3.3 FIG0/21 Frequency Information

See clause A.3. Frequency information could also be provided for the RDS services.

A.5.4 Receiver Behaviour

If the receiver has determined that it needs to switch to an alternative service, and has already exhausted all possibilities to link to an identical programme service, it should refer to FIG0/6 information where the S/H flag is set to 0, indicating soft links.

The receiver should use the same strategy for locating alternative services as described in clause A.3.4 for hard links, but make it clear to the listener that they are being offered a similar service as an alternative, and require the listener to confirm the change rather than it happening automatically.

A.6 Linkage of DAB and FM-RDS services

A.6.1 Problem Description

In an area where DAB signal quality is too low, and the listened service is not available on another frequency signalled as use case 1, 2, 3, 4, a receiver may switch to FM.

In an area where DAB signal quality becomes receivable corresponding to a listened FM service, a receiver may switch to DAB.

The following example represents a case in Switzerland in 2011.

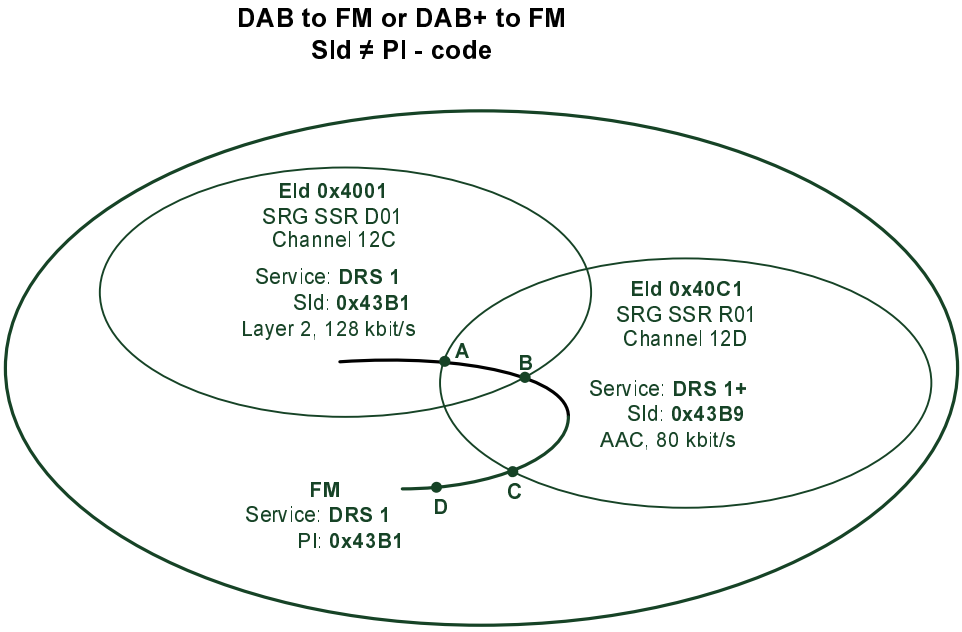

Figure A.5: Ensemble coverage schematic

A.6.2 Concept

In case of direct association PI/SId no additional signalling is needed be transmitted. FIG0/21 may be used to inform receiver about FM frequencies. Implicit linking is considered to be a hard link.

In the example above this applies to the Ensemble 0x4001 where SId and PI code are equal.

Other FIG0/6 may be used to create a link (hard or soft) between an SId and a PI which are not the same.

In the example above this applies to the Ensemble 0x40C1 where SId and PI code are unequal.

Only one hard link may be activated at any given time.

A.6.3 Signalling

A.6.3.1 FIG0/6 Service linking information

In Ensemble **0x40C1**, example above

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Link in active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x123	Linkage Set Number
Rfu	0	1 bit reserved for future use
IsLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	2	Number of Ids in the Id list
Id1	0x43B9	SId of the service in the current ensemble
Id2	0x43B1	PI code of FM services to link with

A.6.3.2 FIG0/24 OE Services

Not required for this use case.

A.6.3.3 FIG0/21 Frequency Information

Frequency Information may be provided but not mandatory for this case. It helps speed up tuning to the FM alternative on a single tuner device. In large FM networks one can end up in a very long list of FM frequencies.

The following list represents the signalling of just one frequency of the example above for the Ensemble 0x40C1.

Field	Value	Description
C/N	0	Start of database
OE	1	Other Ensemble (the frequencies belong to other ensembles)
P/D	0	Not used for Frequency Information
RegionId	000...0	RegionId set to "0000 0000 000", no area is specified
Length of FI list	4	Length in bytes of FI list
Id field (Identifier field)	0x43B1	RDS PI code
R&M	0b1000	FM with RDS
Continuity flag	0	Continuous audio output not expected (audio not co-timed)
Length of Freq. list	1	Length in bytes of the following Freq list
Freq	0x3F	93,8 MHz

A.6.4 Receiver Behaviour

Travelling from point B to D in the example above:

- When leaving point C the DAB reception fails and no other DAB Ensemble can be tuned to.
- If the receiver has determined that it needs to switch to an alternative service, it should refer to the FIG0/6 information.
- In conjunction with Frequency (FIG0/21) information the receiver should try the alternative FM frequency to locate the alternative service, and with an acceptable signal quality.
- The receiver should minimise the time taken to locate the alternative service on FM.

- The receiver should continue to follow the DAB service linking rules even when it has switched to an alternative on FM.

A.7 Linkage of DAB and FM-RDS services with time varying network relationships

A.7.1 Problem Description

In Bavaria, Germany, the service "B1" is provided on FM and DAB. At some times of the day, the same audio programme is provided throughout the region. However, at other times, the programming is split into regional variants. During the main service times all FM transmitters broadcast the same audio programme and share a common PI-code. During the regionalisation times the FM transmitter network is split into several regional variants with different PI-codes. All regional variants are transmitted in parallel on a DAB ensemble as primary audio service components with different SIds..

The service "B1 Oberbayern" is simulcast via DAB and FM. The invariant SId of the service is 0xD411. During the regionalisation times the PI-code changes from 0xD311 to 0xD411. To enable a receiver to follow the service from DAB to FM during the main service times and the regionalisation times both PI-codes (0xD311 and 0xD411) are part of the linkage set (hard link).

Although the PI-code of the FM transmitters change several times throughout the day the linking mechanism can be achieved by a single static linkage set. During the main service times the PI-code 0xD411 is not on air and the receiver will be forced to follow the link indicated by the PI-code 0xD311. When the regional variant is broadcast there is no service with the PI-code 0xD311 transmitted, as consequence the receiver will choose the service with the PI-code 0xD411 as an alternative service.

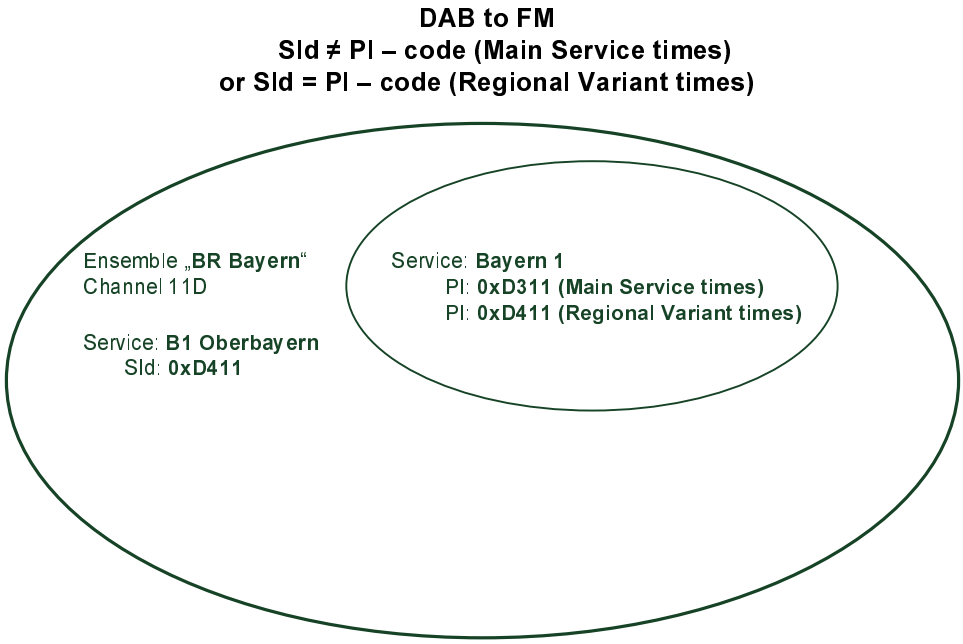

Figure A.6: Ensemble coverage schematic

The coverage areas of the FM regional variants are subsets of the DAB coverage area. All regional variants are always transmitted via the DAB ensemble in parallel. It is possible to receive regional variants via DAB that are not available on FM at a particular location. Therefore it might be useful to additionally soft link the DAB services with all FM regional variants.

A.7.2 Concept

FIG0/6 is used to define a set of hard links to FM services.

FIG0/21 may be provided to give frequency information for those FM services. See clause A.6.

A.7.3 Signalling

A.7.3.1 FIG0/6 Service linking information

Field	Valaue	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage set is active
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x190	Linkage Set Number
Rfu	0	1 bit reserved for future use
IdLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	3	
Id1	0xD411	SId of the service in the current ensemble
Id2	0xD411	PI code of FM service to link with
Id3	0xD311	PI code of FM service to link with

A.7.3.2 FIG0/24 OE Services

Not required for this use case.

A.7.3.3 FIG0/21 Frequency Information

Not required for this use case.

A.7.4 Receiver Behaviour

As general hard linking behaviour - receiver will try both the PI which is equal to the SId code and try the other PI code which is not equal.

A.8 Preventing implicit linkage to FM-RDS

A.8.1 Problem Description

Normally identifiers for DAB and FM-RDS services are drawn from the same pool of codes and regulatory authorities ensure that DAB and FM-RDS services do not have the same identifier unless they are exactly the same service. However, there may be occasions when this is not the case and a broadcaster wants to prevent receivers from service following to FM. In this case the DAB service with SId = 0xC19F carries different audio to the FM-RDS service with the same PI code and the DAB service provider wishes to prevent implicit linking from DAB to FM.

A.8.2 Concept

The "dead link" mechanism is used.

A.8.3 Signalling

A.8.3.1 FIG0/6 Service linking information

Field	Value	Description
C/N	0	Start of database
OE	0	Current Ensemble
P/D	0	Programme service
Id List Flag	1	Long form
Linkage Actuator	1	Linkage is active, do not link
Soft/Hard	1	Hard link
ILS	0	National link
LSN	0x19F	Linkage Set Number
IdLQ	0b01	Each Id represents an RDS PI code
Shd	0	Ids in the list represent a single service
Number of Ids	1	Only Sld is given
Id1	0xC19F	Sld of service that is being 'dead linked'

A.8.3.2 FIG0/24 OE Services

Not required for this use case.

A.8.3.3 FIG0/21 Frequency Information

Not required for this use case.

A.8.4 Receiver Behaviour

Receivers decoding this information disable implicit linking from this service to FM.

Annex B (informative): Transition from existing implementations

Prior to the adoption of the present document, service following implementations were created by various service providers and receiver manufacturers. These implementations may differ in small respects from the rules described in the present document. In general, these differences will not be significant, but in countries where service linking information has been provided for some time and which have a great number of DAB car receivers, special care needs to be taken when changing service following signalling. Some older receivers may not be able to follow all the rules defined in the present document, or may require additional information or information signalled in a different way. Therefore a service provider may choose to create a setup suitable for different generations of receivers for a transition period.

The following differences may occur:

- Some receivers follow a paradigm that if *any* service linking information is provided that *all* implicit linking is disabled. In this case the service provider can provide a linkage set with the SId and PI codes hard linked.
- Some receivers will always follow implicit links between DAB and FM-RDS. If this behaviour is not wanted then SIds should be allocated to avoid this problem.
- Some receivers require that linkage sets are defined with the same SId as the first Id in the list and as a subsequent Id in order to follow a service on different ensembles. Service providers can still provide this signalling under the rules defined in the present document, albeit with a slight signalling overhead.
- Some receivers do not follow soft links. This means that some users may not be linked to the related service and need to select a service manually.

History

Document history		
V1.1.1	August 2012	Publication
V1.1.2	July 2013	Publication