DAB+ Digital Radio

DAB+ System Structure

Head-end Systems

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DAB+ System Structure

1. Head-end Systems
2. Transmission Systems
3. Support Systems

Part 1: Head-end systems

1. Ensemble structure
2. Multiplexing system architecture
3. PAD types and inclusion in ETI Stream
4. Data services
5. Signalling
6. Delay systems

Ensemble Structure

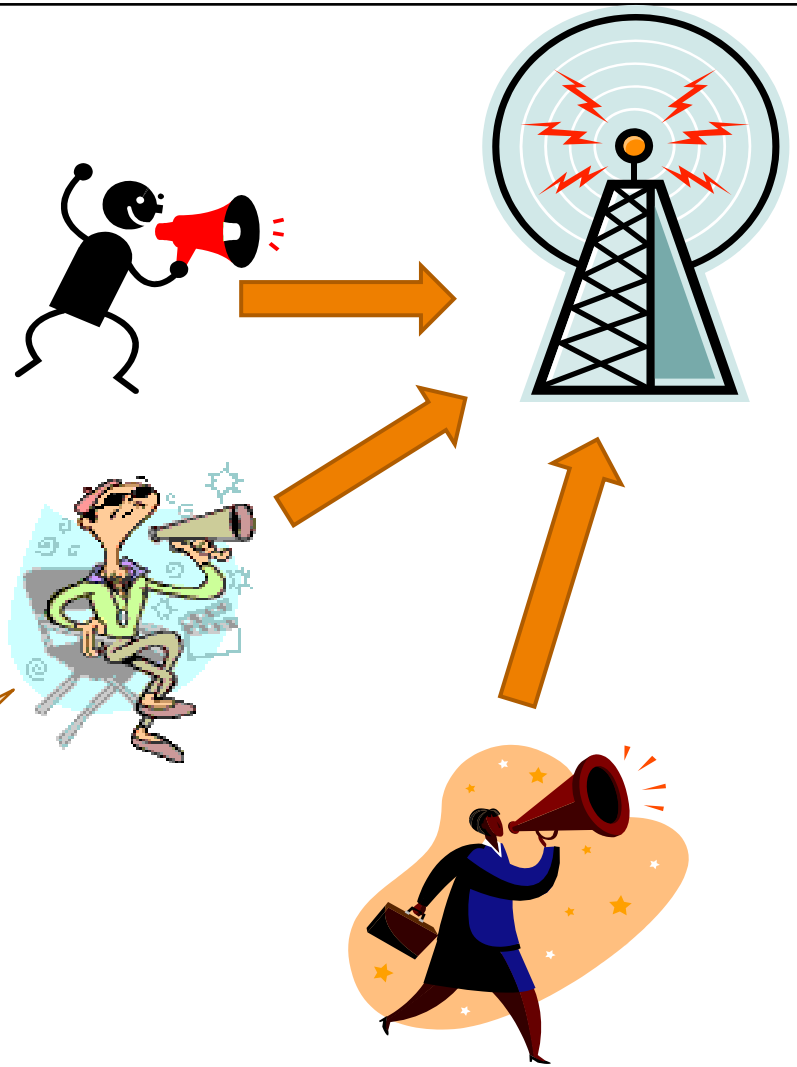
Ensemble structure

Multiple different radio stations transmit on the same frequency

Multiple different radio stations use the same transmitter

Multiple different radio stations share the cost of that single transmission

The flexible ensemble structure allows broadcasters to deliver the content they provide in the most cost effective manner



Ensemble structure

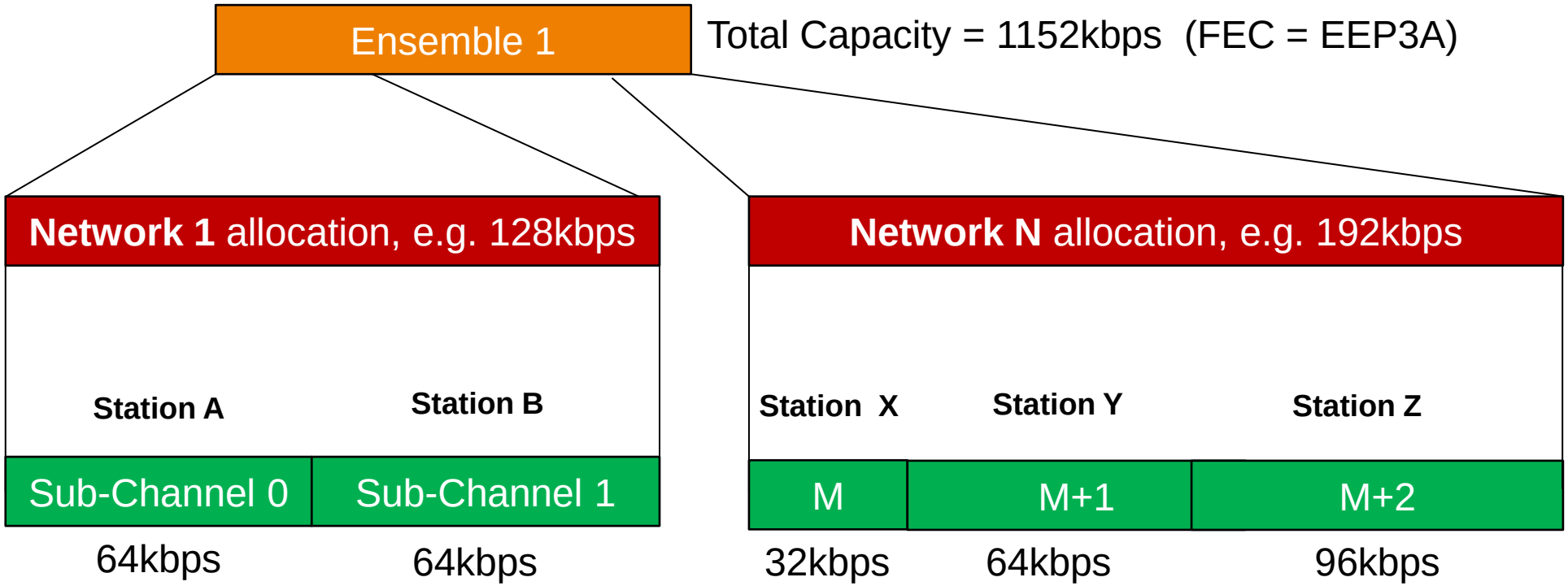
An Ensemble will typically carry multiple services from multiple radio networks, for example:

	Stations (services)	Capacity used
• Radio network 1	2	128kbps
• Radio network 2	4	256kbps
• Radio network 3	3	192kbps
• Radio network 4	9	576kbps
	Total 18 stations	**1152kbps**

- Each network can have their own allocated capacity on the ensemble
  - No other network has access to that capacity

- Each network can **reconfigure** their allocated capacity anytime without impacting the other networks' services
  - **Pop-up services** change their name and sometimes bit rate regularly

Ensemble structure



Ensemble capacity allocated to a network or group of stations can be operated independently of the other capacity allocations within the ensemble

Ensemble structure

Reconfiguration and popup services

Classical music has more bitrate for “concerts on Wednesday’

Network	The Music network		The multi Network			
Network Capacity	128		256			
service bit rate	64	64	64	64	64	64
Service	Pop music	Rock music	Classical music	Mixed music	Regional news	Current affairs
Day						
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday			Sport 1	Sport 2	Sport 3	weekend report / special
Sunday						events
Monday						

The Music network is consistent in content across the whole week

Classical and Mixed music replaced with 3 sport channels on the weekend (3 x 48kbps)

Regional news still operates but on reduced bitrate at the weekend (64 reduced to 32kbps)

Current affairs splits to 2 services on the weekend (48 + 32kbps)

Ensemble structure

Each ensemble has

- its own Ensemble Label
- its own unique Ensemble ID code
- can carry a unique identifying code of the transmitter (TII)
- a Signalling Channel – the Fast Information Channel (FIC)
  - Provides details about all services (stations) carried
    - Service labels
    - Bit rates
    - Data location in the stream
  - Provides details of all data services and PAD
  - Provides announcements and warnings

Fast Information Groups (FIGs) provide a hierarchical structure to deliver information associated with the ensemble and the services / sub-channels contained within it.

Ensemble structure

Ensemble Structure

Each ensemble has 3 main parts

- Main Service Channel (MSC)
  - Contains the services in a Time Division Multiplexed (TDM) format

- Fast Information Channel (FIC)
  - Contains the signals called Fast Information Groups which define the structure and content of the ensemble

- Synchronisation channel (Sync)
  - Adds structure and known signal characteristics to support receivers

Ensemble structure

DAB transmission frame structure

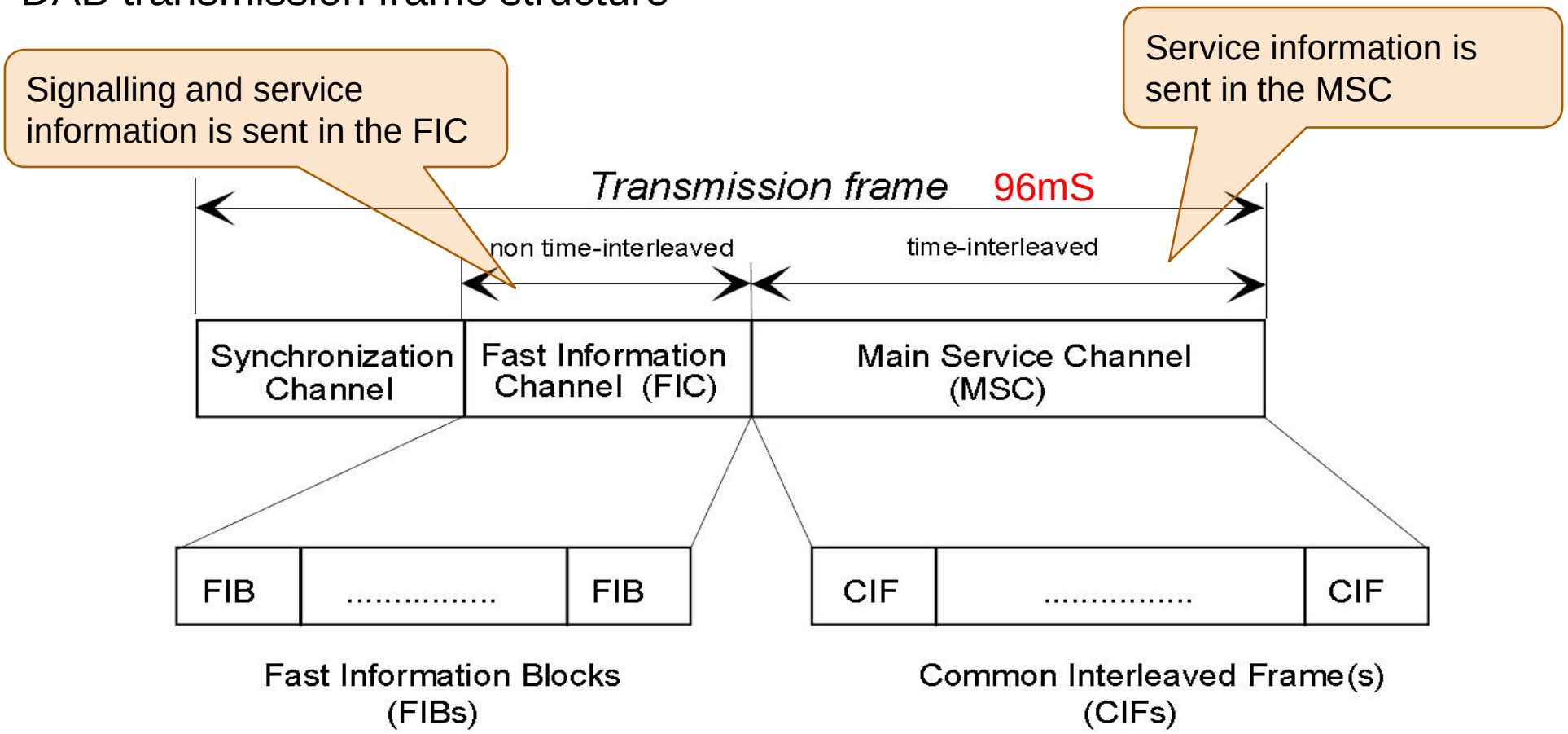


Figure 2: Transmission mode independent description of the FIC and MSC

Ensemble structure

Ensemble Structure

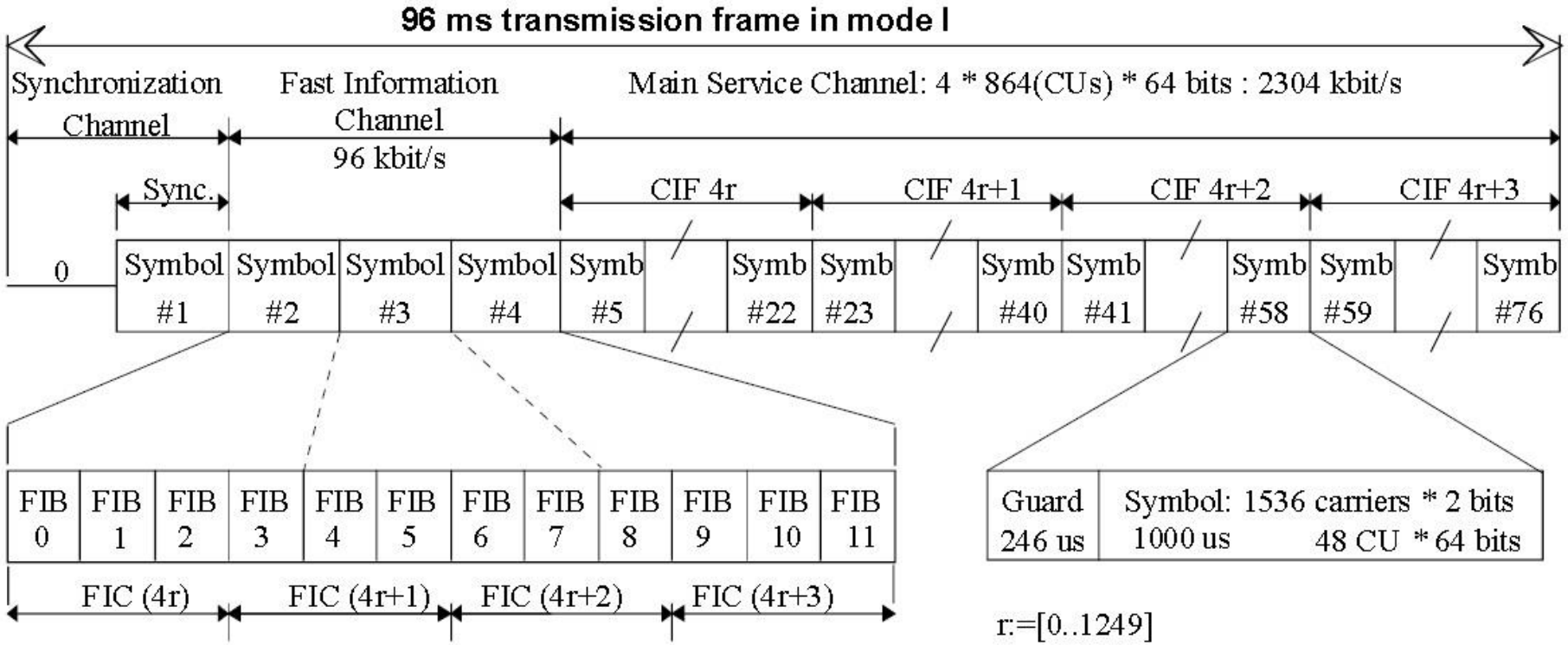


Figure 3.2.1: Structure of Transmission mode I

Ensemble structure

The Fast Information Channel (FIC) provides a range of signals from the head-end system to the receiver

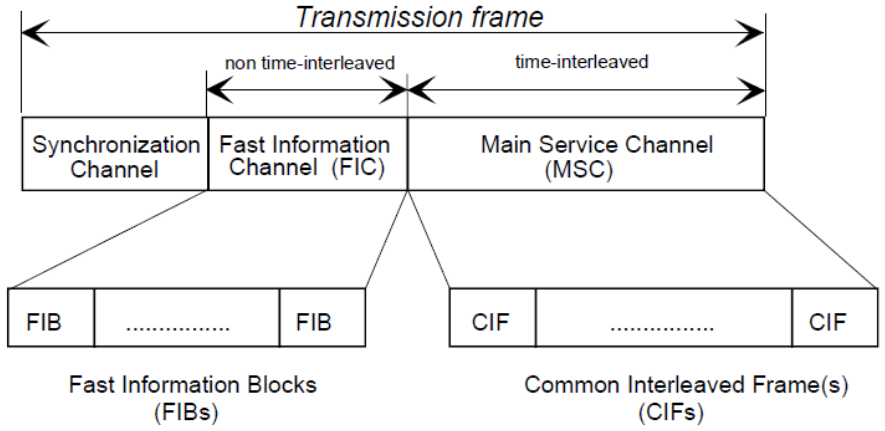


FIG type number	FIG Application
0	MCI and part of the SI
1	Labels, etc. (part of the SI)
2	Labels, etc. (part of the SI)
3	Reserved
4	Reserved
5	Reserved
6	Conditional Access (CA)
7	Reserved (except for Length 31)

FIG type/extension	Description
FIG 0/0	Ensemble information
FIG 0/1	Sub-channel organisation
FIG 0/2	Service organisation
FIG 0/3	Service component in packet mode
FIG 0/4	Service component with CA in stream mode
FIG 0/5	Service component language
FIG 0/6	Service linking information
FIG 0/7	Configuration information
FIG 0/8	Service component global definition
FIG 0/9	Country, LTO and International table
FIG 0/10	Date and time
FIG 0/11 and 0/12	Reserved
FIG 0/13	User Application information
FIG 0/14	FEC sub-channel organisation
FIG 0/15 and 0/16	Reserved
FIG 0/17	Programme Type (PTy)
FIG 0/18	Announcement support
FIG 0/19	Announcement switching
FIG 0/20	Service component information
FIG 0/21	Frequency information
FIG 0/22 and 0/23	Reserved
FIG 0/24	OE services
FIG 0/25	OE announcement support
FIG 0/26	OE announcement switching
FIG 0/27 to 0/31	Reserved

Summary of type 0 FIGs

Service Structure

Part 1: Head-end systems

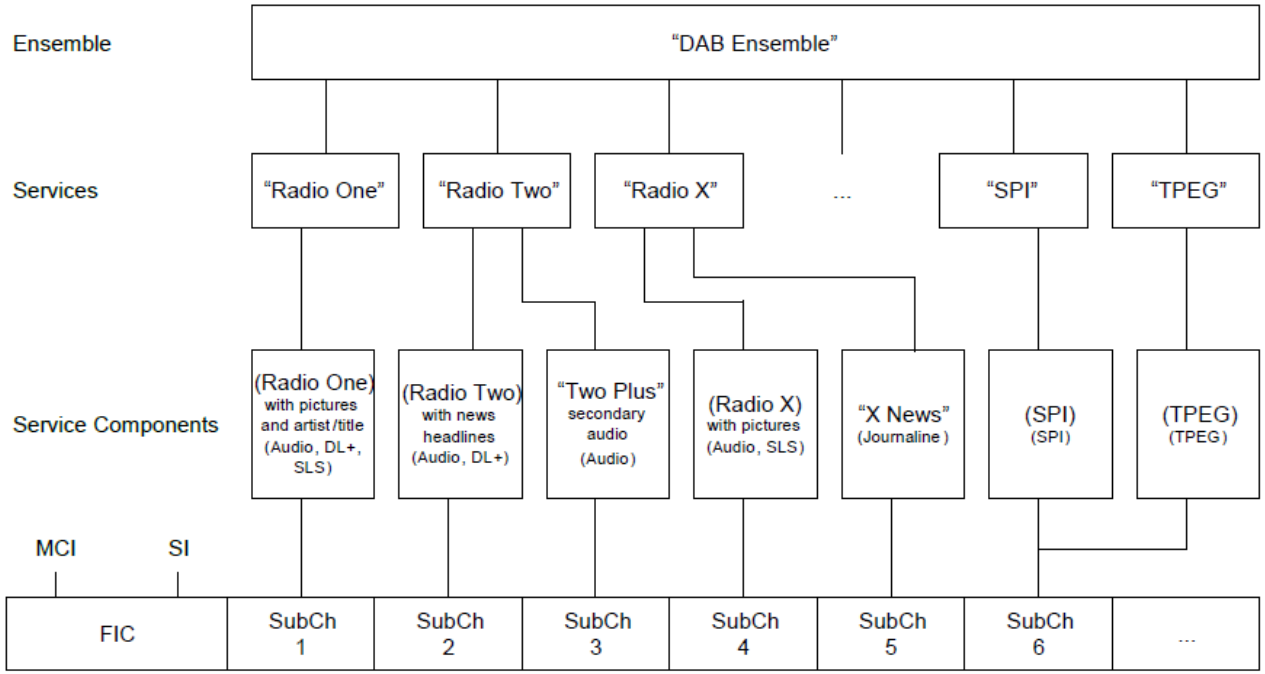
Service Structure

Services and components

Generally 1 service = 1 component

Receivers can deal with multiple service components BUT listeners can get confused!

The MCI is coded in FIG type 0 using Extensions 0, 1, 2, 3, 4, 8 and 14



Service Structure

DAB+ audio

Why DAB+

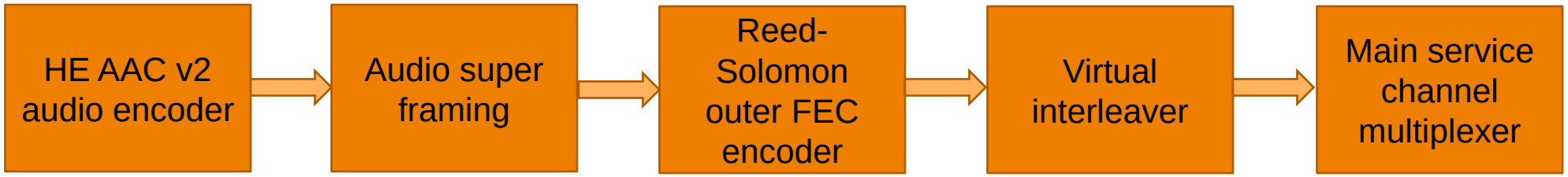
- 2.5 times more audio services than DAB due to the use of HE AAC+ v2
  - Typically 48kbps DAB+ service has the same audio quality as a 128kbps DAB service
- Slightly better coverage : 1 to 2dB better than DAB due to concatenated FEC coding
- Greatly improved signal robustness for Programme Associated Data delivery
- ETSI TS 102 563

System structure

DAB+ audio encoding

Outer layer of FEC coding and interleaving provides protection for PAD – especially important to ensure robust SLS image delivery

Signal Flow with outer layer FEC



Service Structure

DAB+ audio

Many combinations to allow the most cost effective delivery of different audio content types

HE AAC+ V2 audio encoding table combinations

Sampling rate (kHz)	SBR on	Sub-channel data rates (kbps)					
		Stereo		Parametric Stereo		Mono	
		Min	Max	Min	Max	Min	Max
48	no	24	192	-	-	16	176
24	yes	24	136	24	48	16	64
32	no	24	192	-	-	16	168
16	yes	24	136	24	48	16	64

Service Structure

Service Structure: Audio

The number of Audio Units in a Super frame varies dependent on the audio sampling rate and the use of SBR

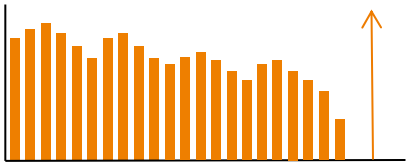
Sampling Rate (kHz)	SBR	Core sampling rate (kHz)	# of frames
32	On	16	2
32	Off	32	4
48	**On**	**24**	**3**
48	Off	48	6

Example: 3 frames of 40mS fit into 5 CIFs of 24ms each to create the super frame

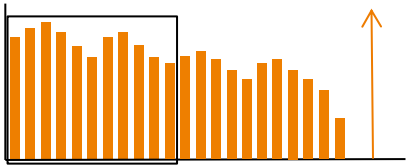
System structure

DAB+ audio coding – spectral band replication (SBR)

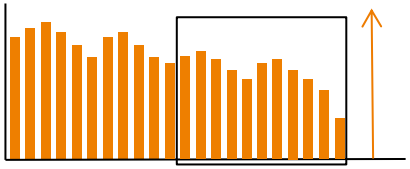
128kbps



64kbps – high frequencies removed

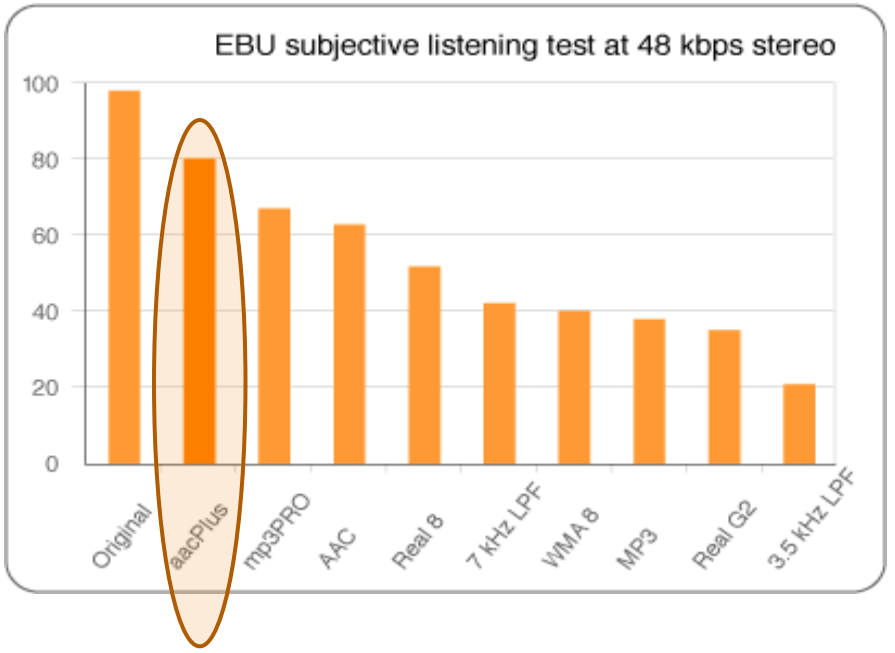


64kbps with high frequencies SBR encoded



Efficient sample rate and bit rate reduction method

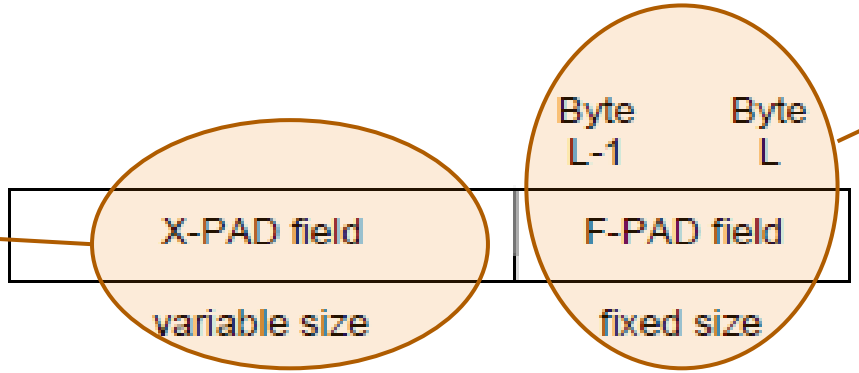
Only slight audio degradation



System structure

DAB+ Audio channel PAD

PAD for DLS and SLS delivery



XPAD size, music/speech flag, command channel

Figure 2: Coding of the PAD field

Table 10: Maximum bit rate of F-PAD and X-PAD data

AAC core sampling rate	Maximum bit rate for F-PAD data (2 bytes)	Maximum bit rate for X-PAD data (196 bytes)
16 kHz	267 bps	26 133 bps
24 kHz	400 bps	39 200 bps
32 kHz	533 bps	52 267 bps
48 kHz	800 bps	78 400 bps

Typical use: SBR on @ 24kHz core sampling rate, 3 frames per super-frame, 1 super-frame per 120mS

Service Structure

PAD SlideShow

- Further strengthens the audio message
- Standalone advertising during song items
- Promotion of station activities
- Traffic and weather reports
- Sports results and stock market information
- Local news, happenings, community events

System structure

DAB+ Audio bit rates v PAD bit rate

Need to ensure the correct balance between audio bit rate, audio settings and PAD

Audio bit rate ≈ Sub-Channel bit rate *0.9 – PAD bit rate

SLS images are best synchronised with audio using pre-delivered images and header update display triggers, either

TriggerTime = time/date or

TriggerTime = now

Sub-Channel bit rate (kbps)	FEC Overhead 10%	Payload capacity (kbps)	PAD (kbps)	Audio bit rate (kbps)
32	3.2	28.8	1	27.8
32	3.2	28.8	2	26.8
32	3.2	28.8	4	24.8
32	3.2	28.8	8	20.8
48	4.8	43.2	1	42.2
48	4.8	43.2	2	41.2
48	4.8	43.2	4	39.2
48	4.8	43.2	8	35.2
64	6.4	57.6	1	56.6
64	6.4	57.6	2	55.6
64	6.4	57.6	4	53.6
64	6.4	57.6	8	49.6
64	6.4	57.6	16	41.6
80	8	72	1	71
80	8	72	2	70
80	8	72	4	68
80	8	72	8	64
80	8	72	16	56

Service Structure

Programme Associated Data (PAD)

Programme Associated Data includes

- Dynamic Label Segment (DLS) – Text
- SlideShow (SLS) – images
    - Trigger Time
    - Advanced features
        - Categorised SLS
            - Adds structure and storage
        - Click-through URL
        - Alternative Image URL

PAD is transported in using Multimedia Object Transport (MOT)

- Transported in XPAD
    - Main = EN 300 401 MOT = TS 101 499
    - SPI = TS 102 818 Binary transport TS 102 371

Service Structure

Programme Associated Data (PAD) - parameters

Table 3: MOT Parameters

Parameter	Parameter Id	Specified in	Mandatory for service provider		Mandatory for receiver		Occurrence
			Normal mode	Interactive mode	Normal mode	Interactive mode	
ContentName	0x0C	MOT ETSI EN 301 234 [3]	Yes	Yes	Yes	Yes	Single
TriggerTime	0x05	The present document	No (if not present, the object shall be triggered by a "Header update" (see clause 6.3) or it will never be presented	No	Yes	Yes	Single
ExpireTime	0x04	The present document	No	No	No	Yes	Single
CategoryID/SlideID	0x25	The present document	No	Yes	No	Yes	Single
CategoryTitle	0x26	The present document	No	No (But has to be received at least once. see 5.3.5.3)	No	Yes	Single
ClickThroughURL	0x27	The present document	No	No	No	No	Single
AlternativeLocationURL	0x28	The present document	No	No	No	No	Single
Alert	0x29	The present document	No	No	No	Yes	Single

Part 1: Head-end systems

Service Structure: Audio Bit Rates v PAD Bit Rate

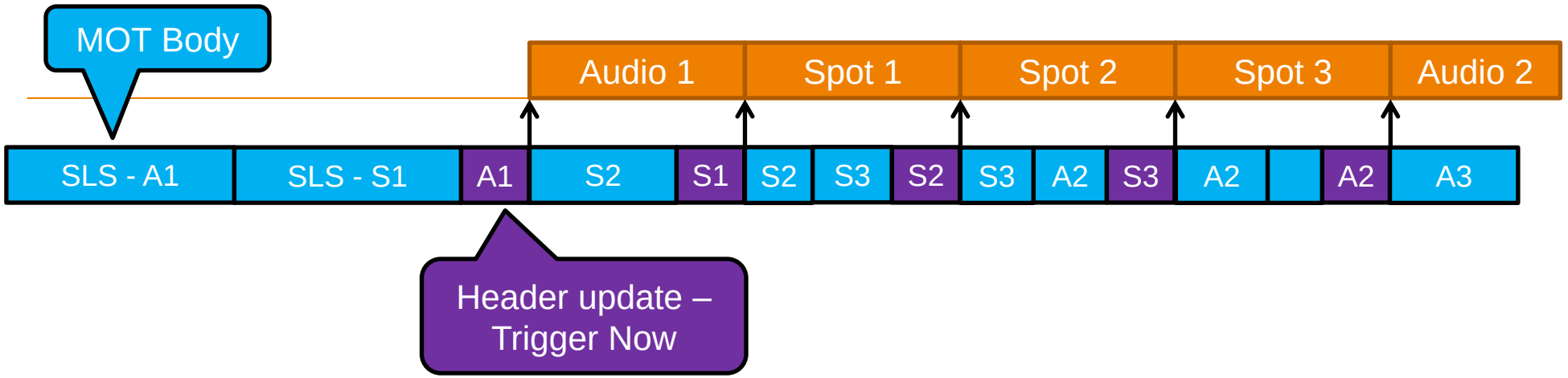
Trigger Time Now in Header Update

Remove?

Service Structure

Slideshow delivery

Header Update – Trigger Now



SlideShow images are sent in MOT bodies ahead of the time that they are required to be displayed

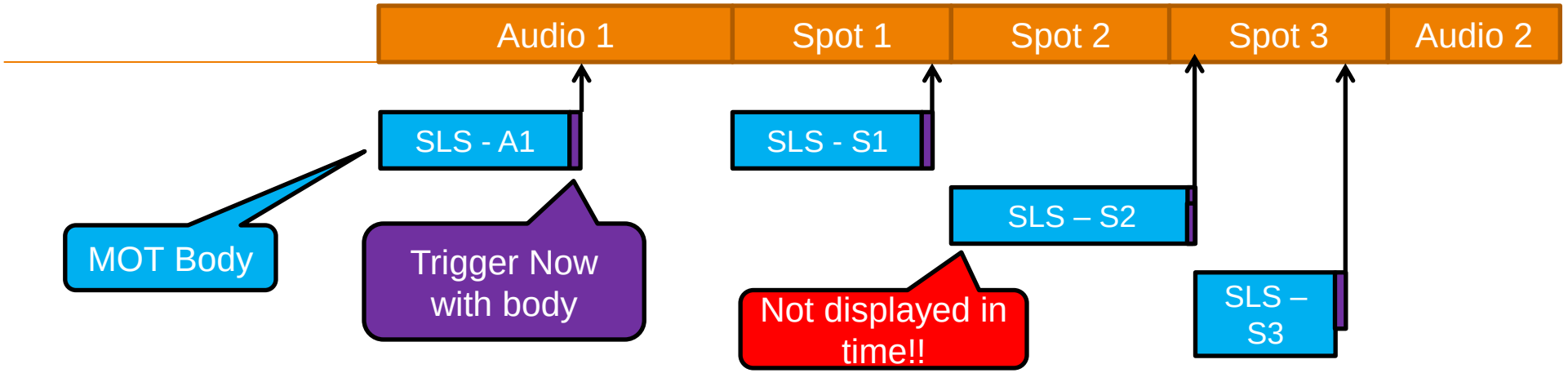
Header Updates can be inserted between MOT body segments to ensure timing accuracy

Still requires a PAD Server to send the Trigger Now at the start of the audio event

Service Structure

Programme Associated Data - Slideshow (SLS) Images

Header / Body – Trigger Now



SlideShow images are sent in MOT bodies when the audio event starts

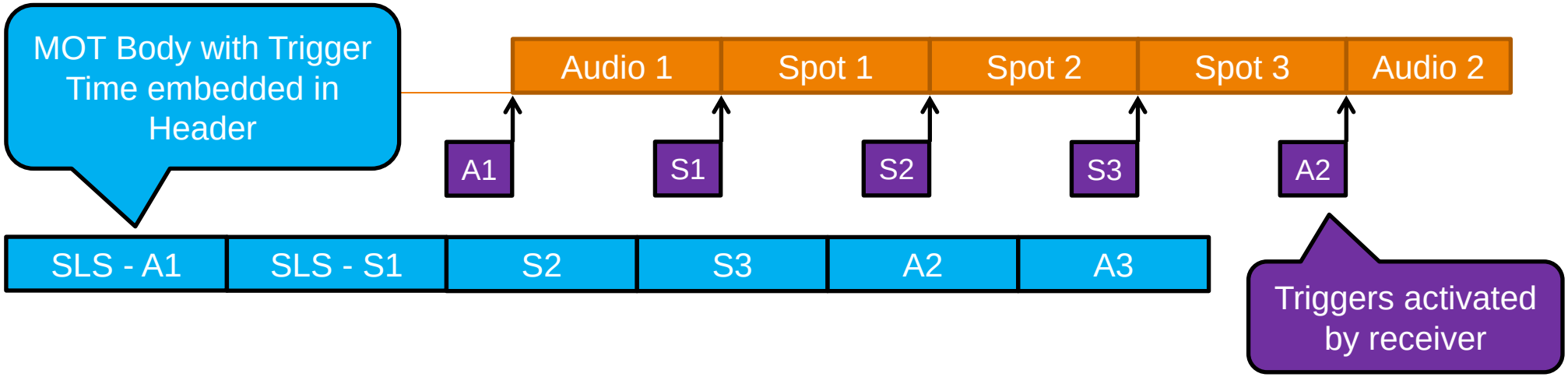
The MOT object includes the body (image) and a Trigger Now command in the associated Header

<u>The image display ALWAYS lags the audio event start</u>

Service Structure

Programme Associated Data - Slideshow (SLS) Images

Header / Body – Trigger Time



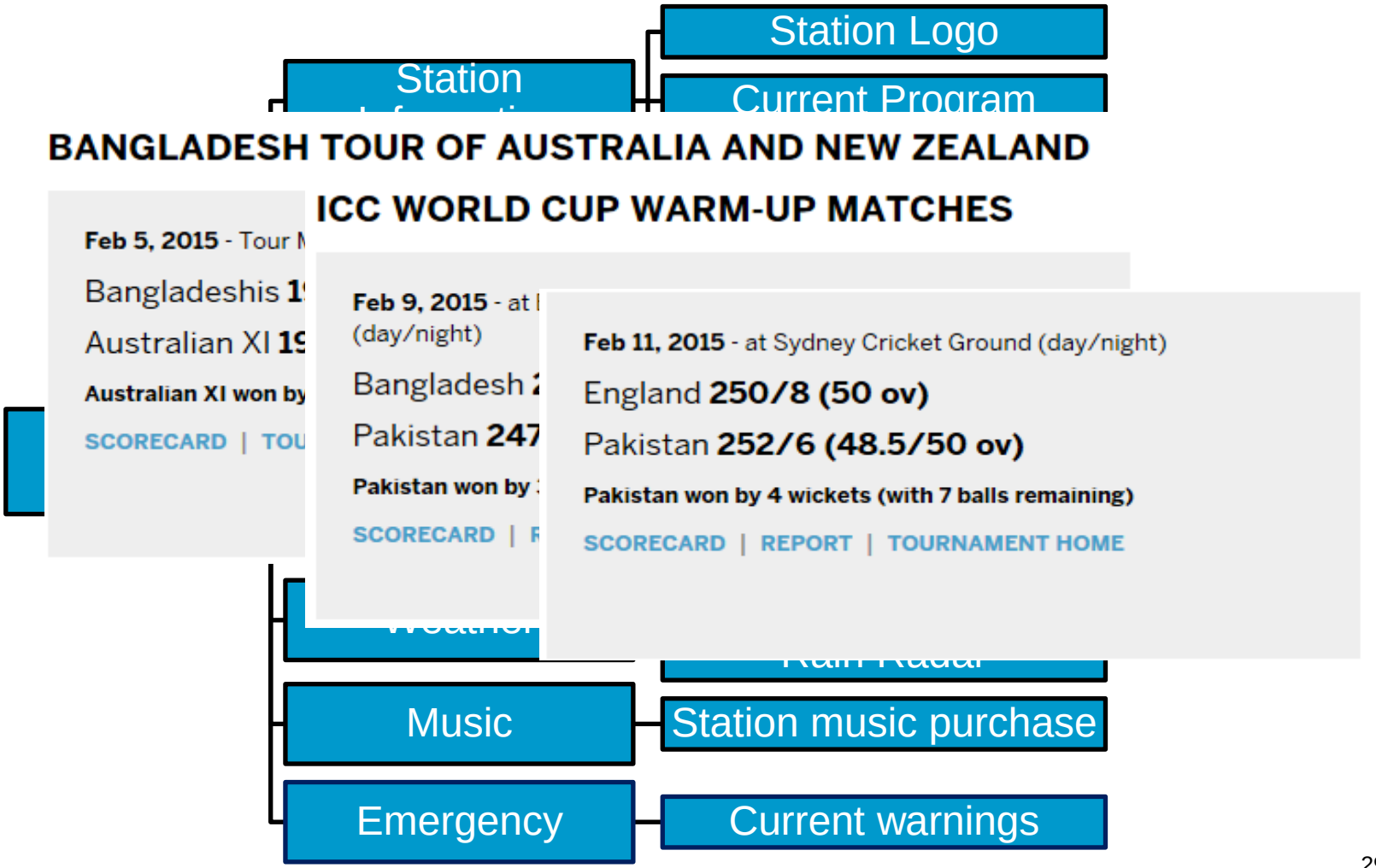
SlideShow images are sent in MOT bodies ahead of the time that they are required to be displayed

Header with the body includes an Absolute Trigger time – Trigger Time is calculated by the PAD server given the delivery timing of previous audio objects and their duration

Maximum download efficiency and accuracy

Service Structure

Categorised SlideShow



Service Structure

Service Structure: Service and Programme Information (SPI)

SPI is defined in XML format in TS 102 818
SPI provides information about the services and the Service Provider

Service:

- nameGroup (shortName, mediumName, longName)
- mediaDescription
- genre
- keywords
- link
- bearer
- radiodns
- geolocation
- serviceGroupMember
- shortName
- mediumName

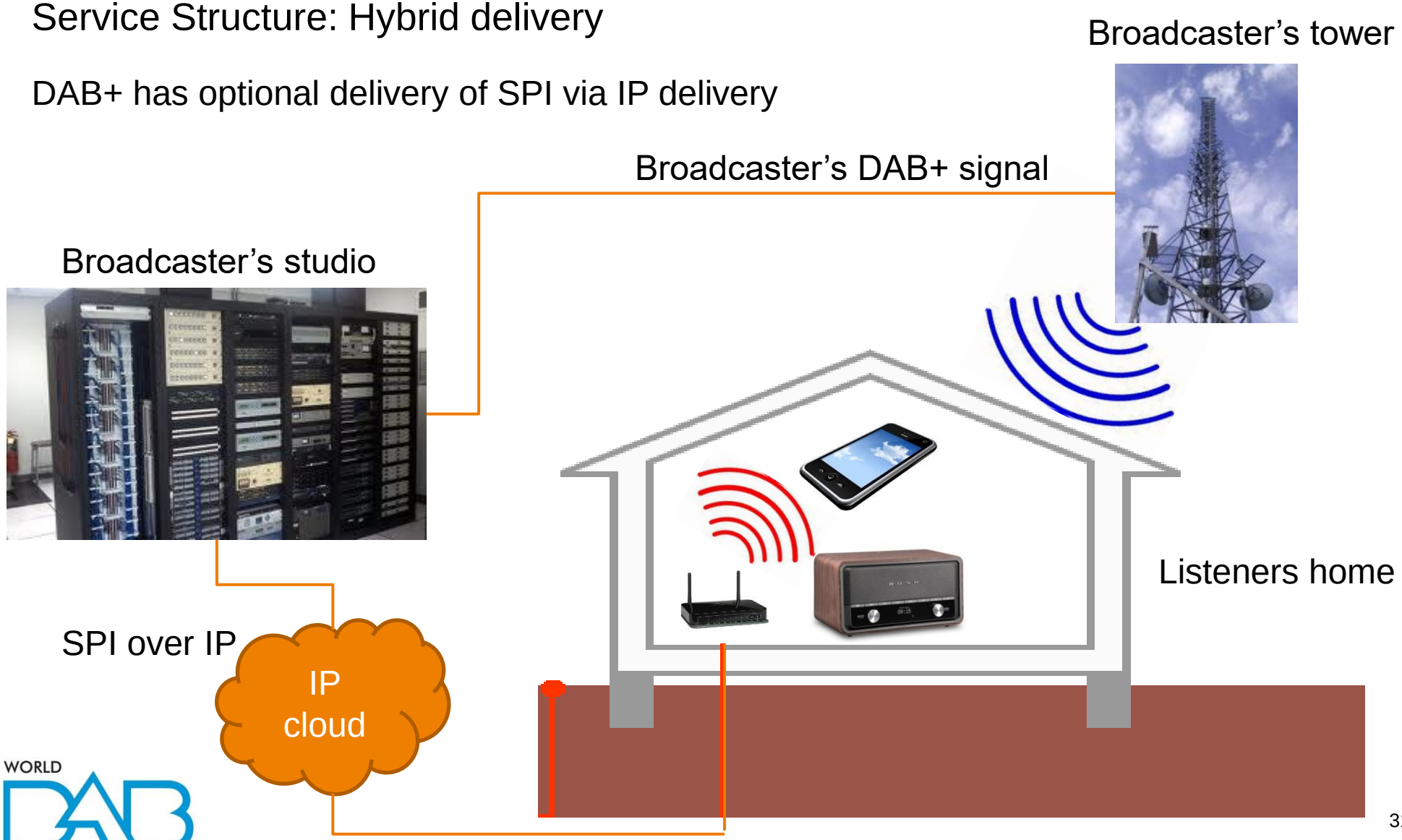
Service Provider:

- nameGroup (shortName, mediumName, longName)
- mediaDescription
- keywords
- link
- geolocation
- shortName;
- mediumName.

Service Structure

Service Structure: Hybrid delivery

DAB+ has optional delivery of SPI via IP delivery



Service Structure

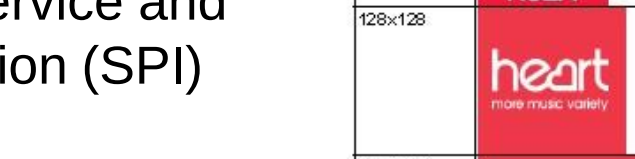
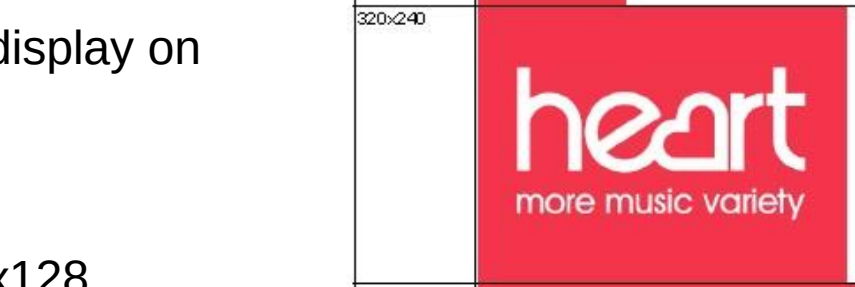
Service Structure: Service and Programme Information (SPI)

SPI includes logos for display on image capable devices

Broadcast delivery
- 32x32, 112x32, 128x128, 320x240

IP delivery
- 32x32, 112x32, 128x128, 320x240, 600x600, 1024x768

Table D.1: Example logo sizes and parameters

Size (width x height in pixels)	Example	Size for PNG (in kB)
32x32		0,8
112x32		1,3
128x128		4,9
320x240		14,7
600x600		21,7

Service Structure

Minimal SI info example

```
<?xml version="1.0" encoding="UTF-8"?>
<serviceInformation xmlns="http://www.worlddab.org/schemas/spi/31"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.worlddab.org/schemas/spi/31 spi_31.xsd"
   creationTime="2014-04-25T00:05:31+01:00" originator="Global Radio"
   xml:lang="en">
   <services>
      <service>
         <shortName>Capital</shortName>
         <mediumName>Capital FM</mediumName>
         <mediaDescription>
            <multimedia url="http://owdo.thisisglobal.com/2.0/id/25/logo/32x32.png"
                        type="logo_colour_square" />
         </mediaDescription>
         <mediaDescription>
            <multimedia url="http://owdo.thisisglobal.com/2.0/id/25/logo/112x32.png"
                        type="logo_colour_rectangle" />
         </mediaDescription>
         <mediaDescription>
            <multimedia url="http://owdo.thisisglobal.com/2.0/id/25/logo/128x128.png"
                        type="logo_unrestricted" mimeValue="image/png" height="128" width="128" />
         </mediaDescription>
         <mediaDescription>
            <multimedia url="http://owdo.thisisglobal.com/2.0/id/25/logo/320x240.png"
                        type="logo_unrestricted" mimeValue="image/png" height="240" width="320" />
         </mediaDescription>
         <mediaDescription>
            <multimedia url="http://owdo.thisisglobal.com/2.0/id/25/logo/600x600.jpg"
                        type="logo_unrestricted" mimeValue="image/jpeg" height="600" width="600" />
         </mediaDescription>
         <genre href="urn:tva:metadata:cs:ContentCS:2004:3.6.10" />
         <bearer id="dab:ce1.c185.c479.0" mimeValue="audio/mpeg" offset="2000" cost="20" />
      </service>
   </services>
</serviceInformation>
```

Service structure

Data services

Enhanced Packet Mode

Data services are uni-directional (UDP)

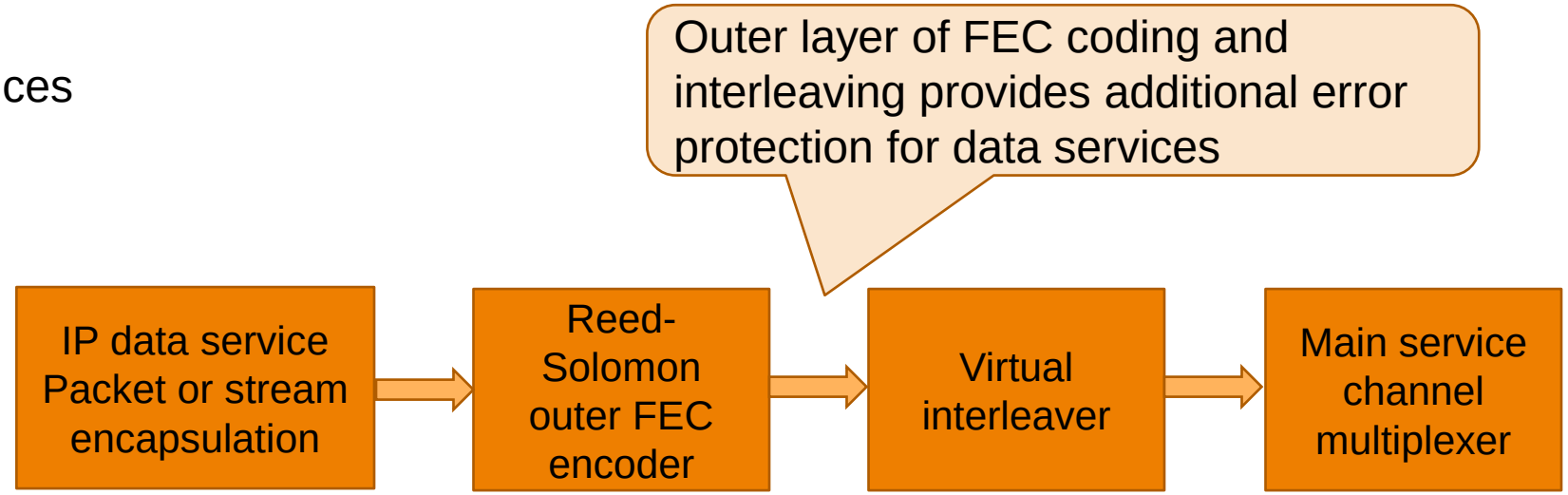
Outer layer coding adds significant protection for data services - RS(204,188)

Need specific applications to process the data on the receiver

Can be made secure though the use of encryption / Conditional Access

Example services

- TPEG
- Journaline



Service structure

Data Services

Can be delivered using MOT files in directory mode
Can be delivered as separate services, e.g. TPEG
Can be delivered in Fast Information Data Channel

- delivered in FIC in lieu of signalling information

Traffic e.g. TMC and TPEG provide up to the moment information on

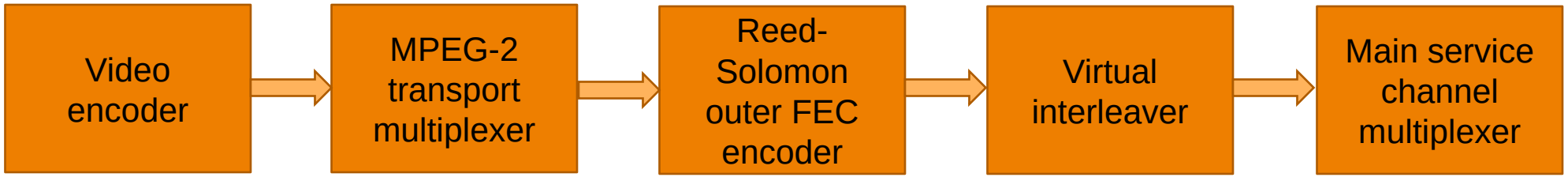
- current traffic flow and congestion
- fuel locations and prices
- parking

Service structure

Video services : T-DMB

Video service structure

Example receiver e.g. LG smartphone



Service structure

Forward Error Correction (FEC) codes are applied per sub-channel

Comparative performance

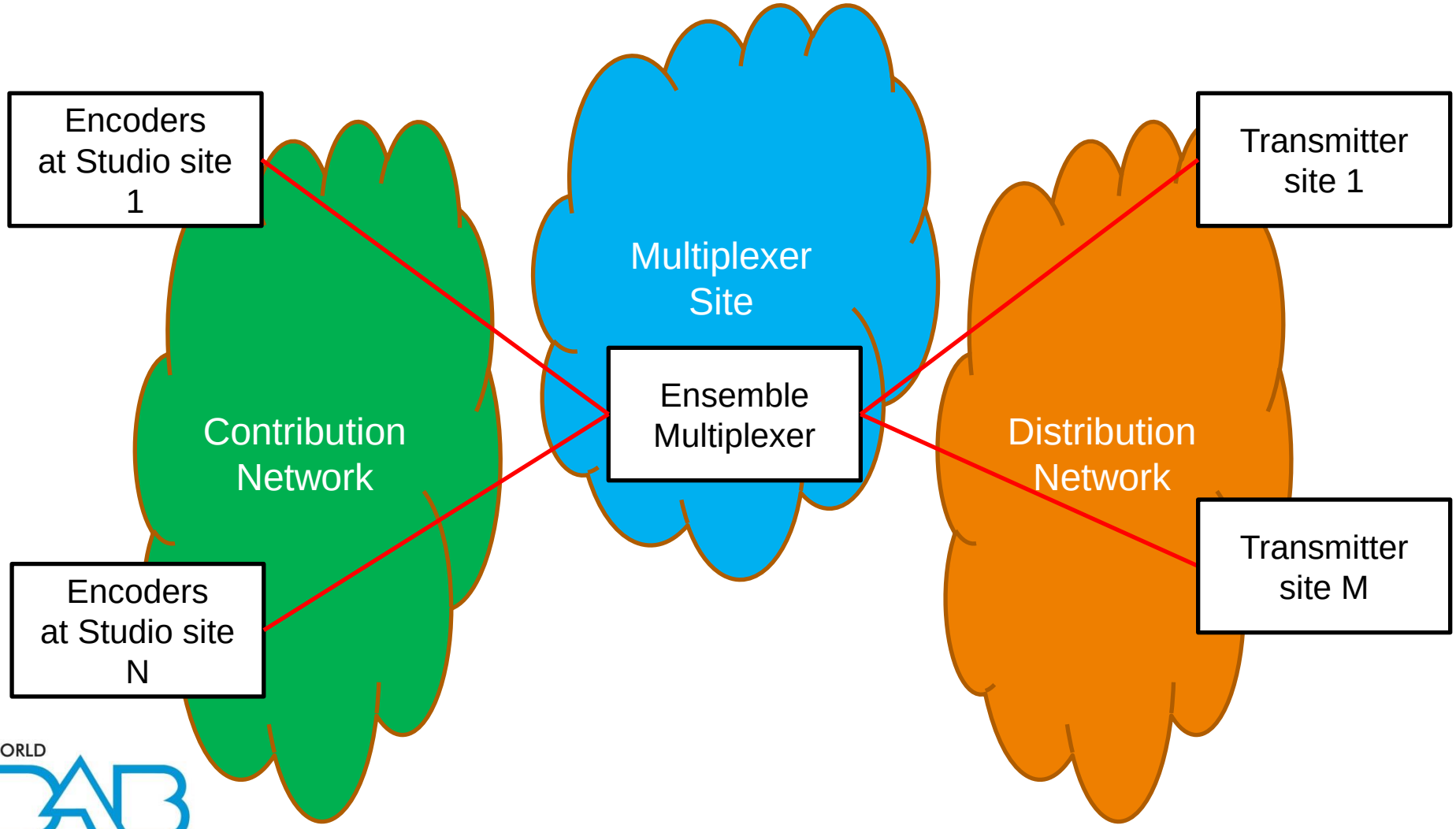
FEC Code	Code Rate	Capacity (kbps)	Number of 64kbps channels	Approximate power required relative to 3A
1A	1/4	576	9	-3 to -6dB
2A	3/8	864	13	-2 to -3dB
3A	1/2	1152	18	0
3B	2/3	1536	24	+3dB
4A	3/4	1728	27	+6dB

Payload capacity and transmit power can be traded
Stronger FEC protection = lower capacity BUT lower power for the same coverage area

Systems and networks

System and networks

System Architecture: Network overview



System and networks

Example DAB+ network

Repeater Transmitter

COFDM

IP is generally preferred for both contribution and distribution networks

Studio 1

PAD system

Audio Encoders x N

Local Controller

Service Mux (Opt)

Studio K

PAD system

Audio Encoders x M

Local Controller

Service Mux (Opt)

Contribution Telecoms cloud

Broadcast System

Ensemble Controller

EMUX

DMUX

Distribution Telecoms cloud

Switch / Router

Studio and multiplexer site equipment can now be virtualised on single servers

COFDM

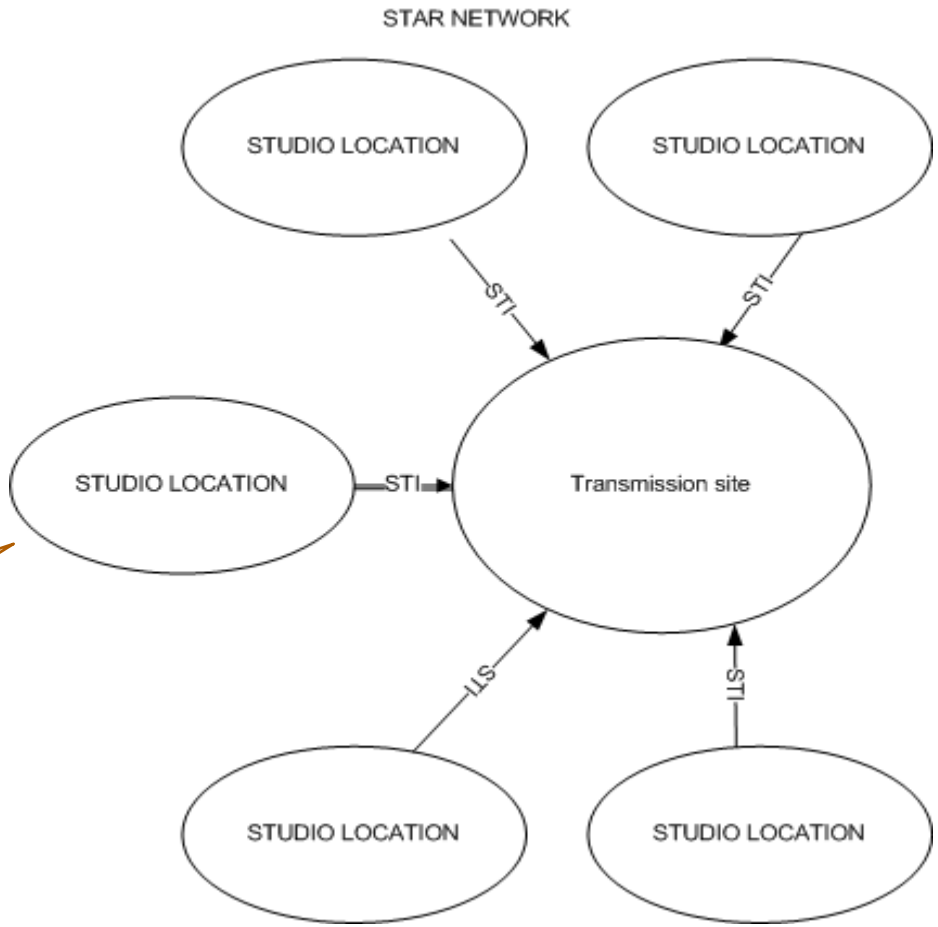
Main Transmitter

System and Networks

Star network

- Central multiplexing equipment
- Individual links per studio site
- Simple networking
- Stations are in control of their content
- Privacy

This architecture is often used for stand-alone / isolated installations such as single city or area transmissions

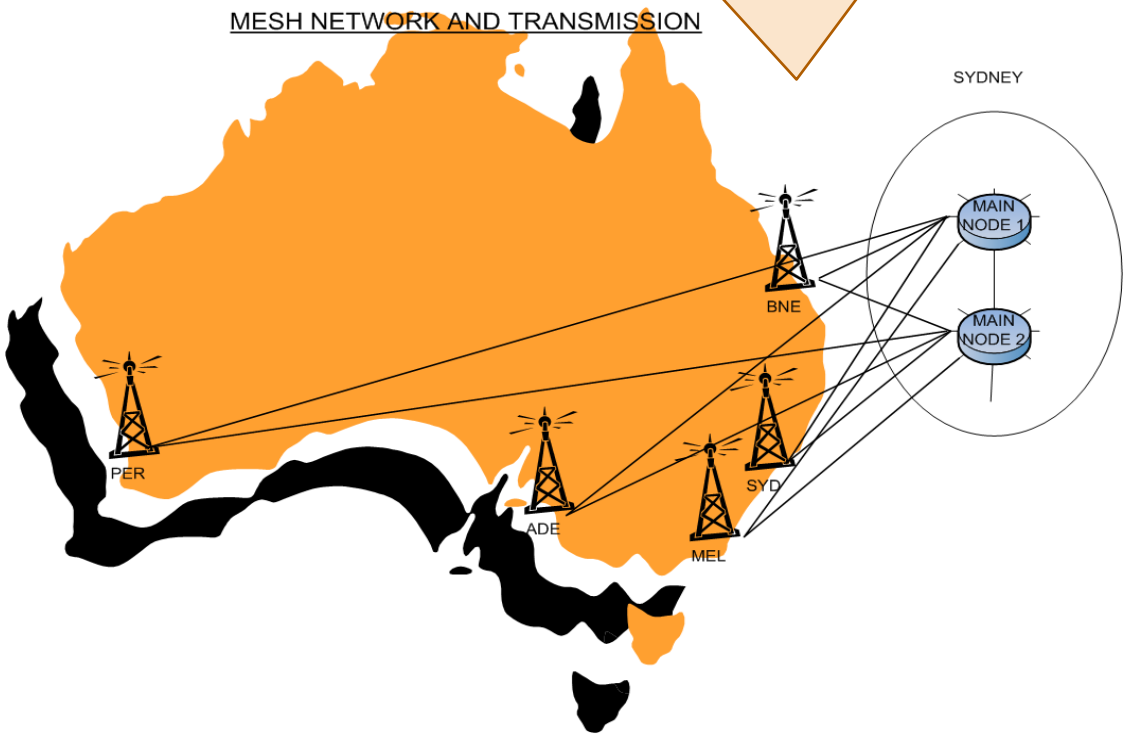


System and Networks

Mesh network

Suitable for distributed broadcast networks such as national multi-studio networks

- Transparent interconnect between sites
- High Redundancy and Reliability
- Typically uses a multicast enabled VPN
- Content produced at any site can be transmitted at any site



System and networks

Types of systems

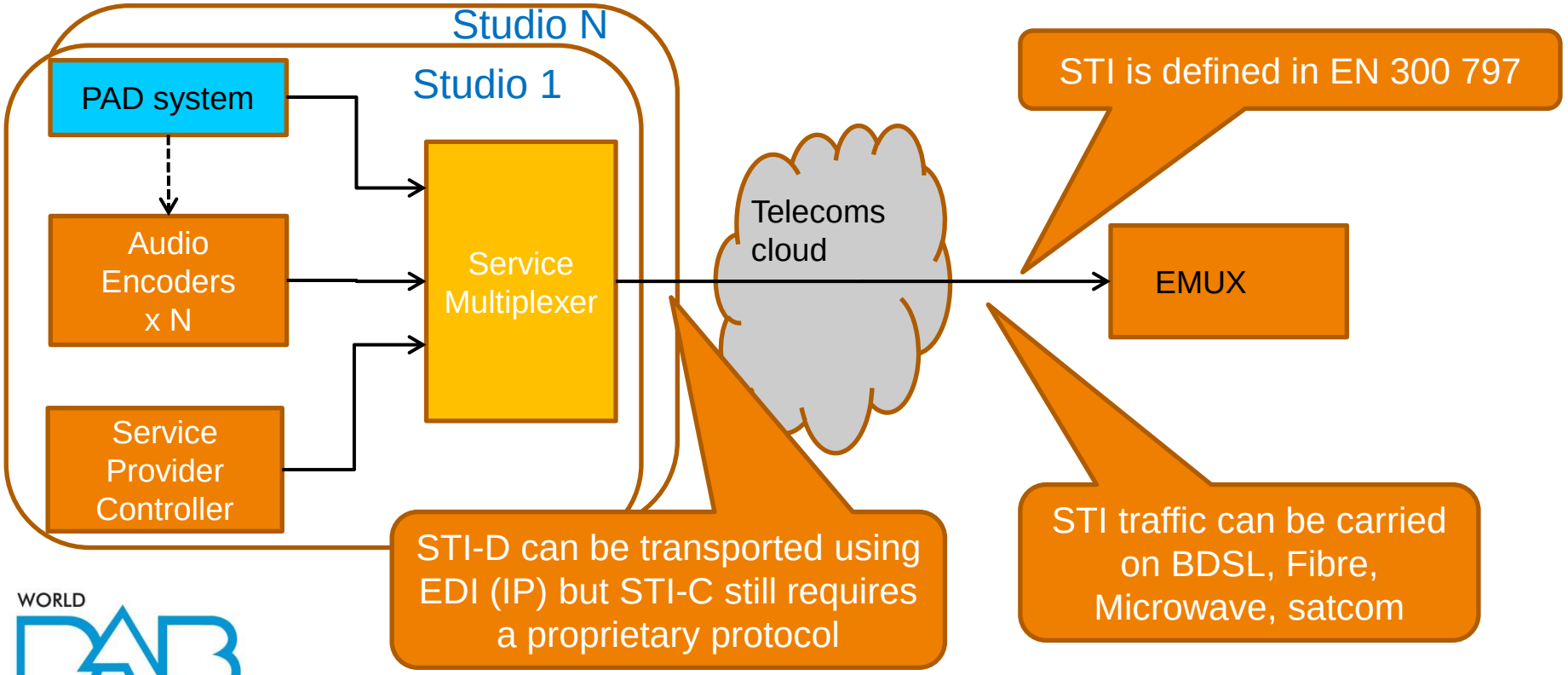
- Traditional – service multiplexer based
- Advanced – virtual service multiplexer
- Distributed vs centralised
- Virtualised
- Cloud based

System and networks

System Architecture: Contribution – STI based

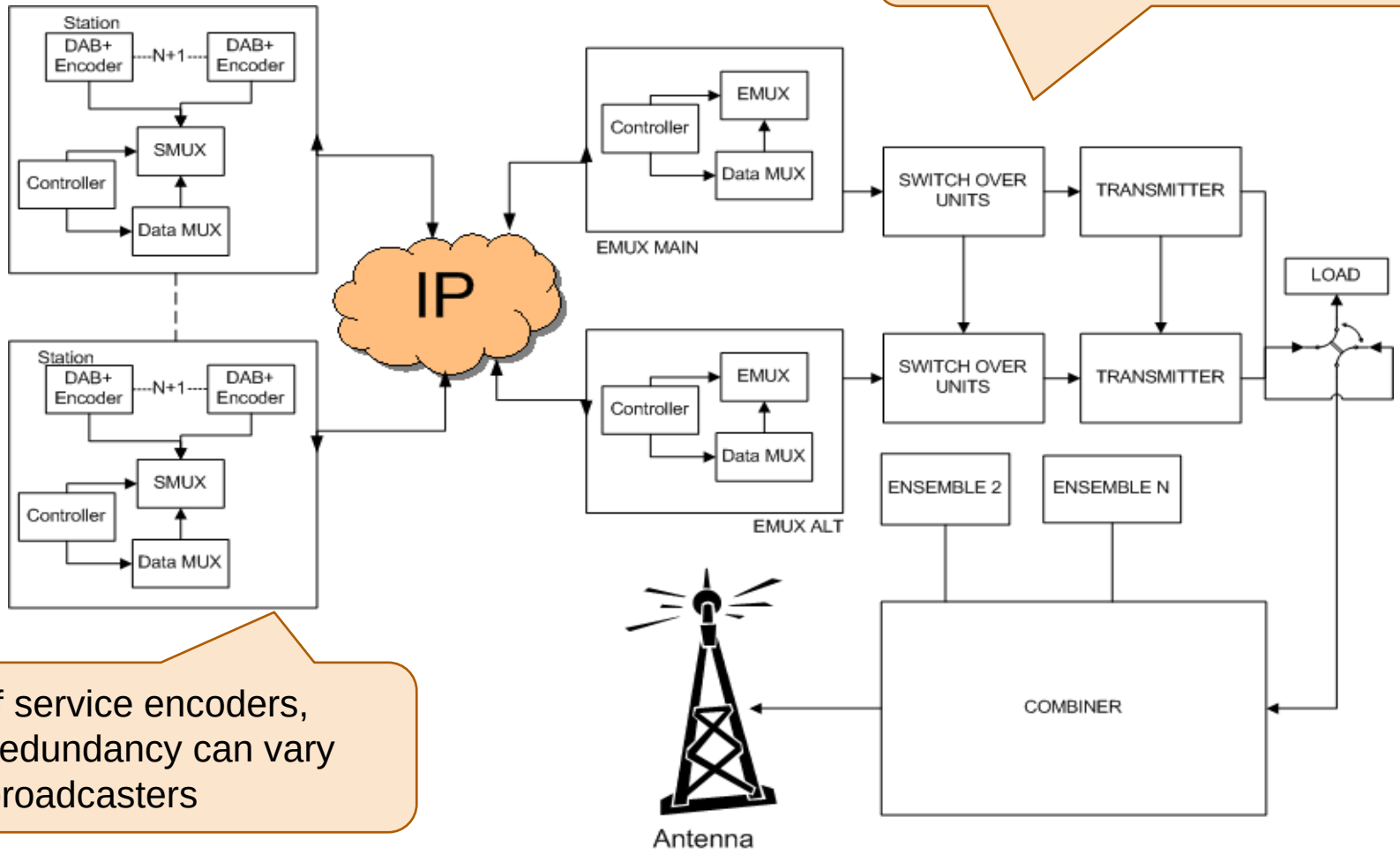
Service Transport Interface (STI) based system use a Service Multiplexer at the Service Providers location which gathers all of the Service Provider's contribution and feeds it to the Ensemble Multiplexer.

STI is usually transported using G.703 or a proprietary IP protocol



System and Networks

Star network



System and networks

System Architecture: Contribution – STI based

Advantages of STI based systems

- Conform with the DAB+ standards
- Lower Opex than Cloud
- User owned

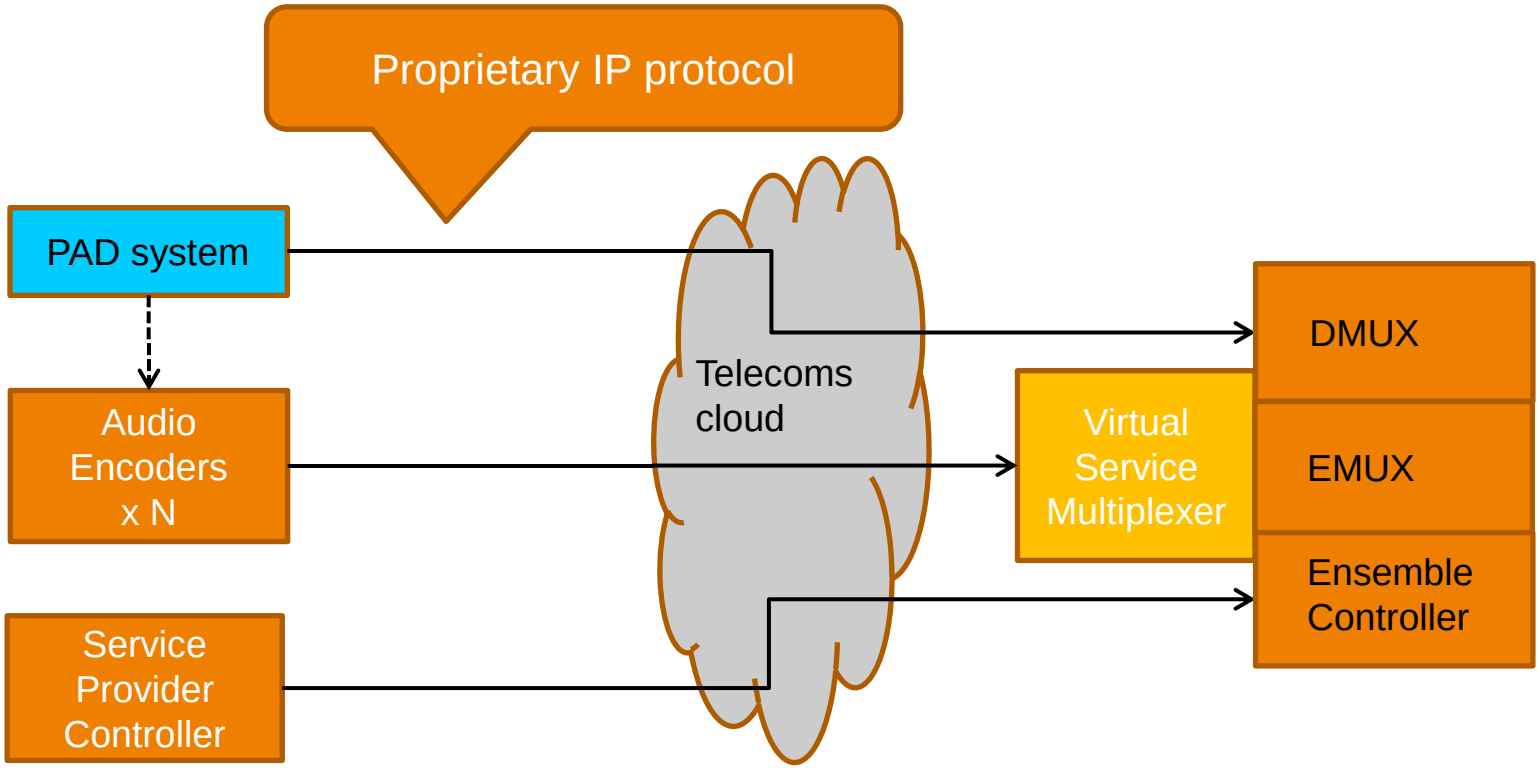
Disadvantages

- More equipment than IP or Cloud based systems = higher Capex
- Overly redundant systems can have higher failure rates
- STI overheads require additional contribution network capacity / cost even if IP encapsulation is used

System and networks

System Architecture: Contribution – IP based

Direct IP based systems use a Virtual Service Multiplexer and always operate using IP



System and networks

System Architecture: Contribution – IP Based

Advantages of IP based systems

- Lowest cost of ownership and Opex
- Minimum contribution and distribution network capacity / costs
- User owned
- Initial Capex less than STI based systems

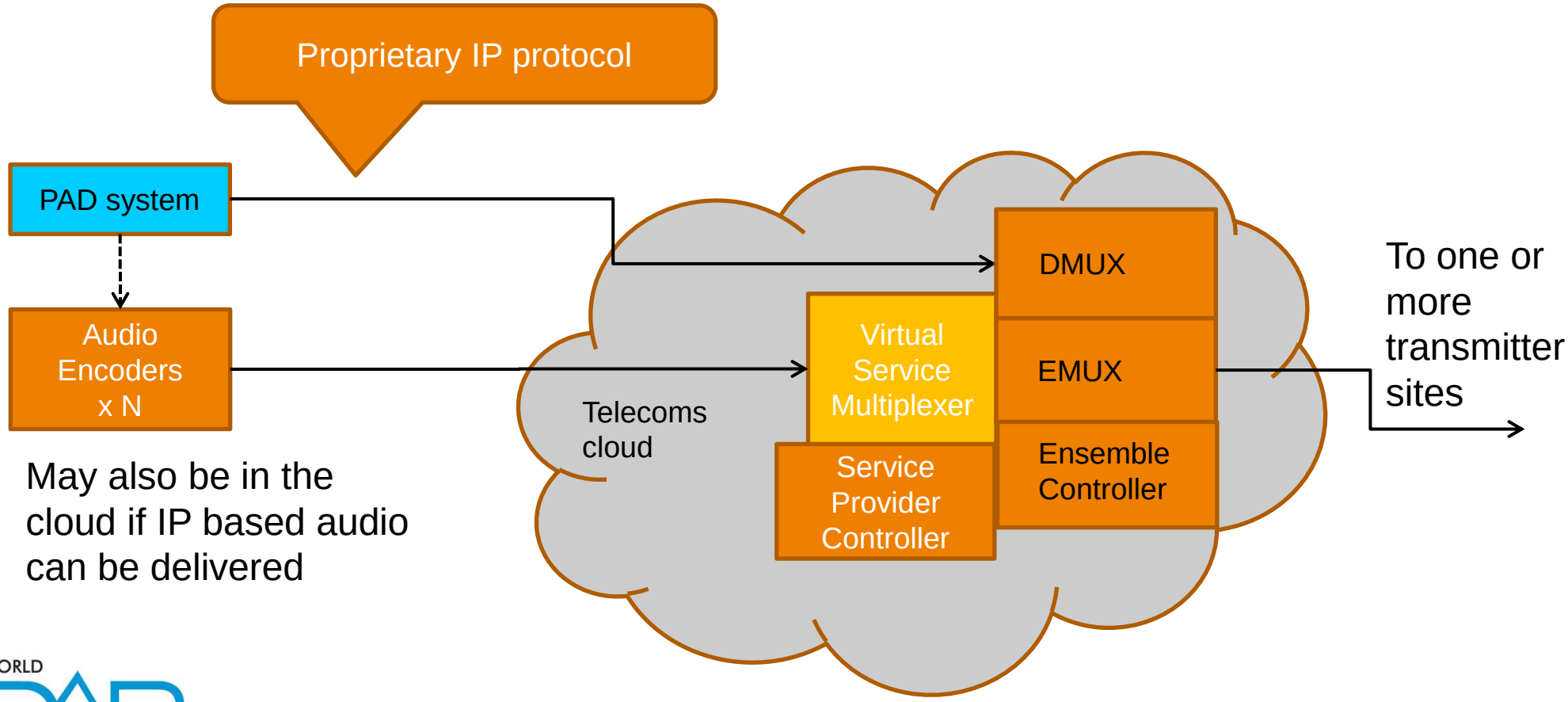
Disadvantages

- Uses a proprietary contribution network protocol
- Higher Capex than Cloud based

System and networks

System Architecture: Contribution – cloud based

Cloud Based systems have the EMUX, DataMux and controllers in the Cloud



System and networks

System Architecture: Contribution – Cloud Based

Advantages of cloud based systems

- The EMUX, DMUX and controller functionality is run Virtually on managed servers
    - High reliability
    - Simple redundancy model
- Quickly setup
- Run as a managed service (at the moment)
    - Maintenance and operations included
- Initial costs are low BUT may require a long term contract

Disadvantages

- Long term higher costs for multiplexer functionality
- Usually incurs additional data transmission costs due to additional circuits being required for the ETI output
- Requires the use of Telco services for contribution network – higher cost than dedicated microwave links

System and networks

System Architecture: Contribution - Redundancy

Purpose

- Minimise service interruptions
  - Equipment failures
  - Equipment servicing and maintenance

Cost Benefit

- Increases as the listening population increases
- Redundancy can be added in stages to spread Capex over time
- Need a minimum amount to counter potential long periods of outage

Types

- None
- N+1
- 1+1

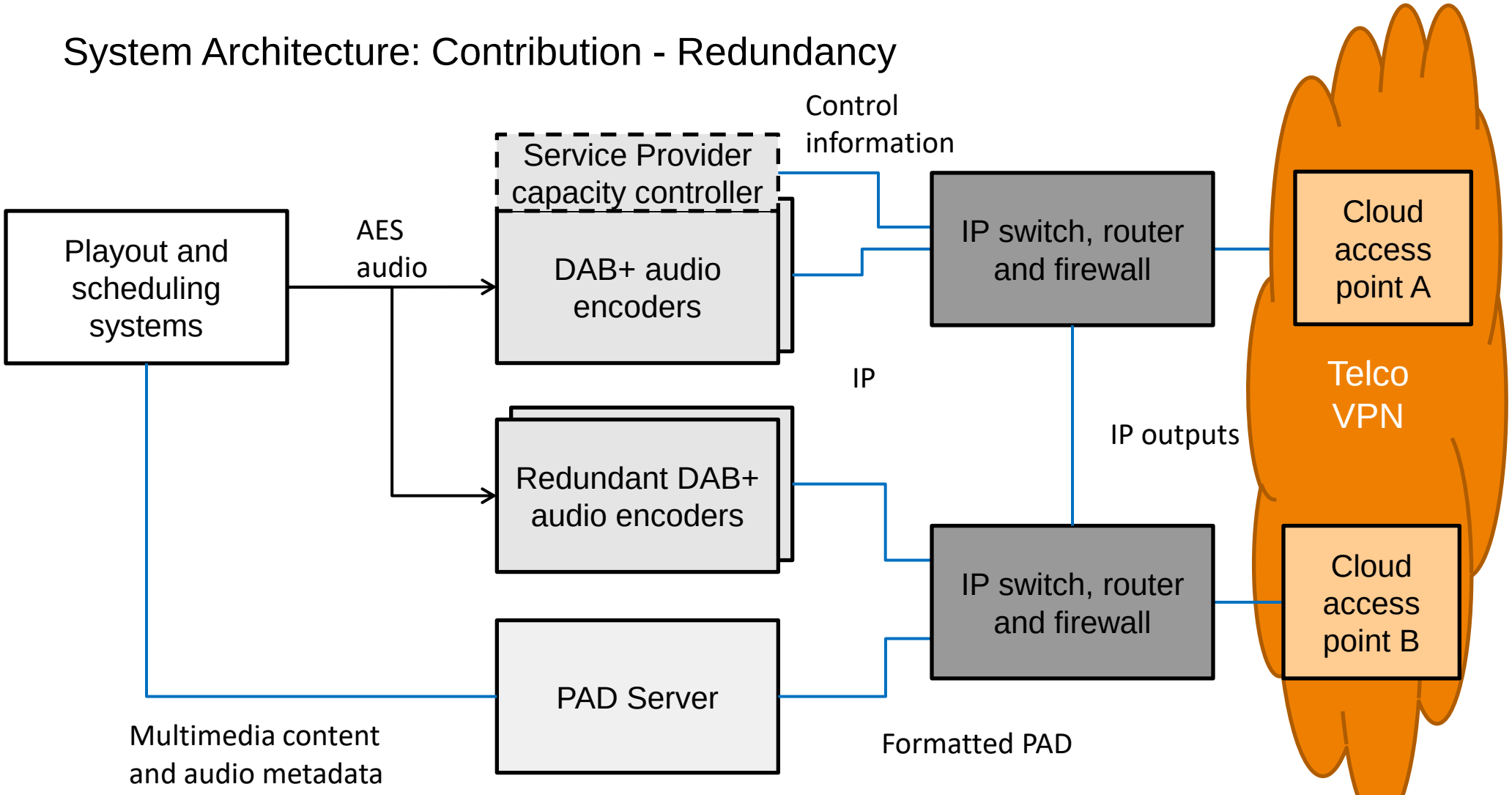
System and networks

System Architecture: Contribution - Redundancy

Equipment options	Audio Service Interruption					
	Failure			Maintenance		
	None	N+1	1+1	None	N+1	1+1
• Studio						
• Encoders	Y	Y	N	Y	N	N
• Service Controller	N	N	N	N	N	N
• Studio to EMUX link	Y	-	N	Y	-	N
• PAD Server	N	N	N	N	N	N
• Multiplexer Sites						
• Ensemble Multiplexer	Y	-	N	Y	-	N
• Ensemble Controller	N	N	N	N	N	N
• Data Multiplexer	N	N	N	N	N	N
• NTP server	Y	-	N	Y	-	N
• NMS	N	N	N	N	N	N

System and networks

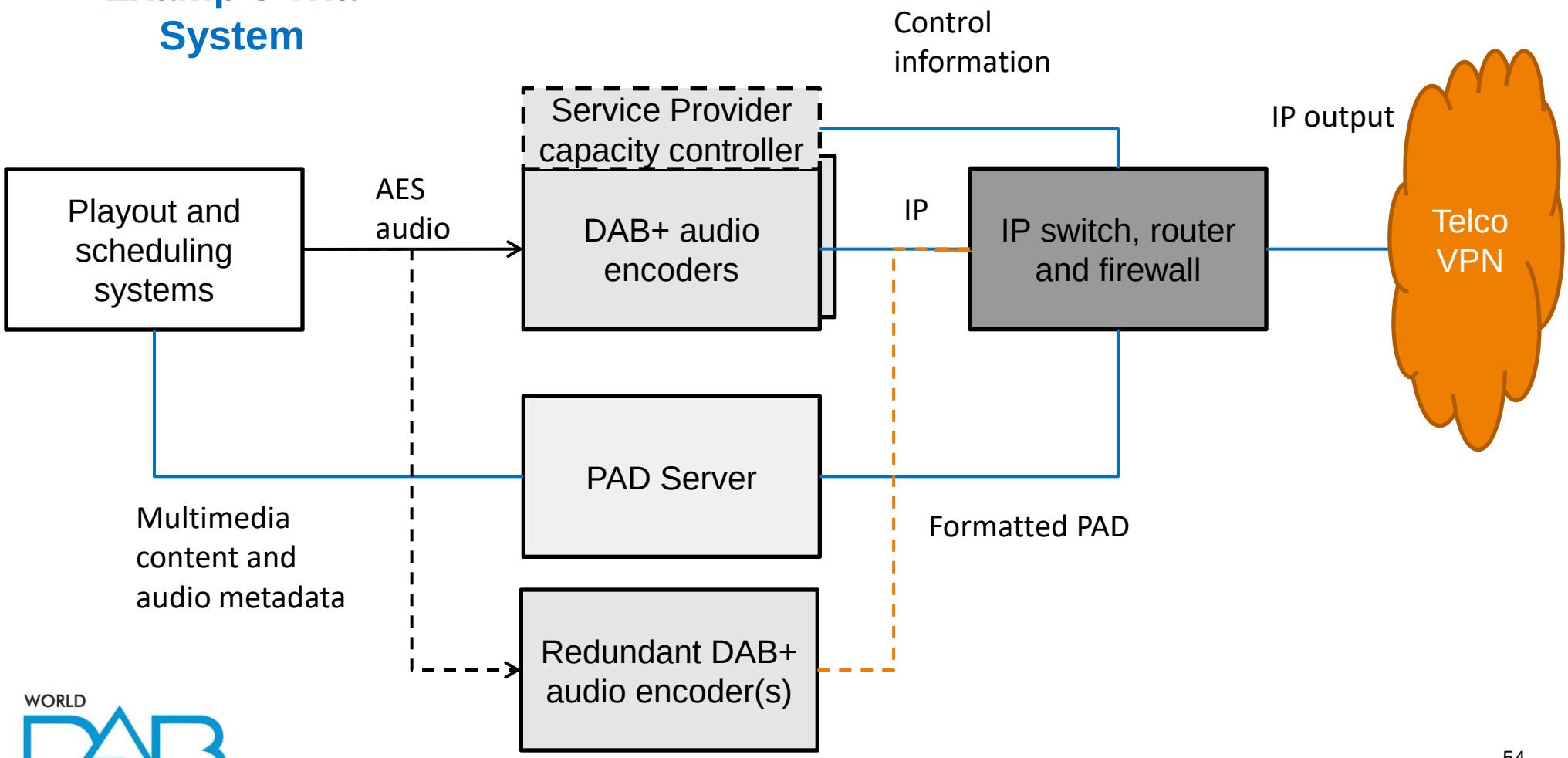
System Architecture: Contribution - Redundancy



System and networks

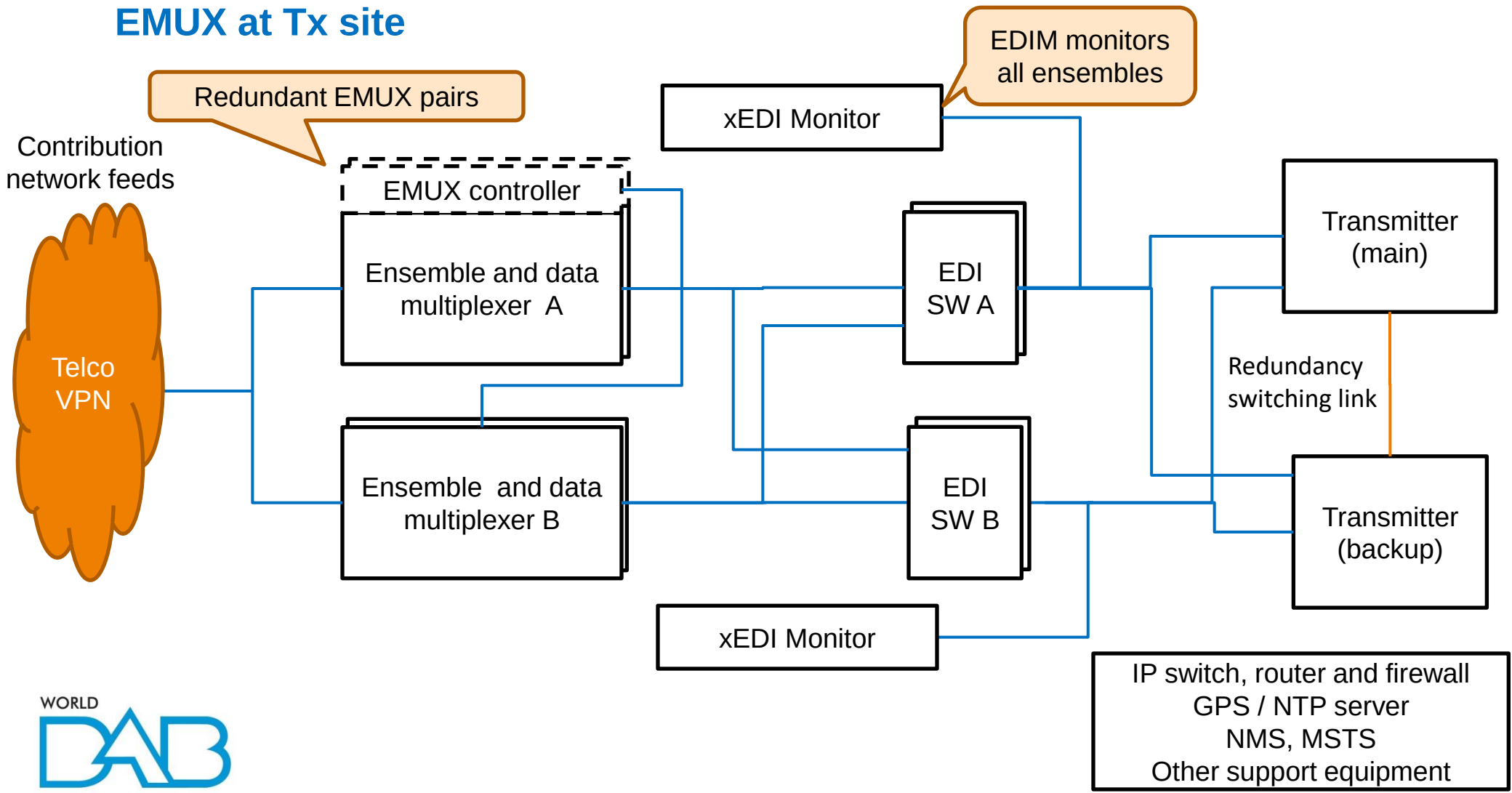
System Architecture: Contribution - Redundancy

Example Trial System



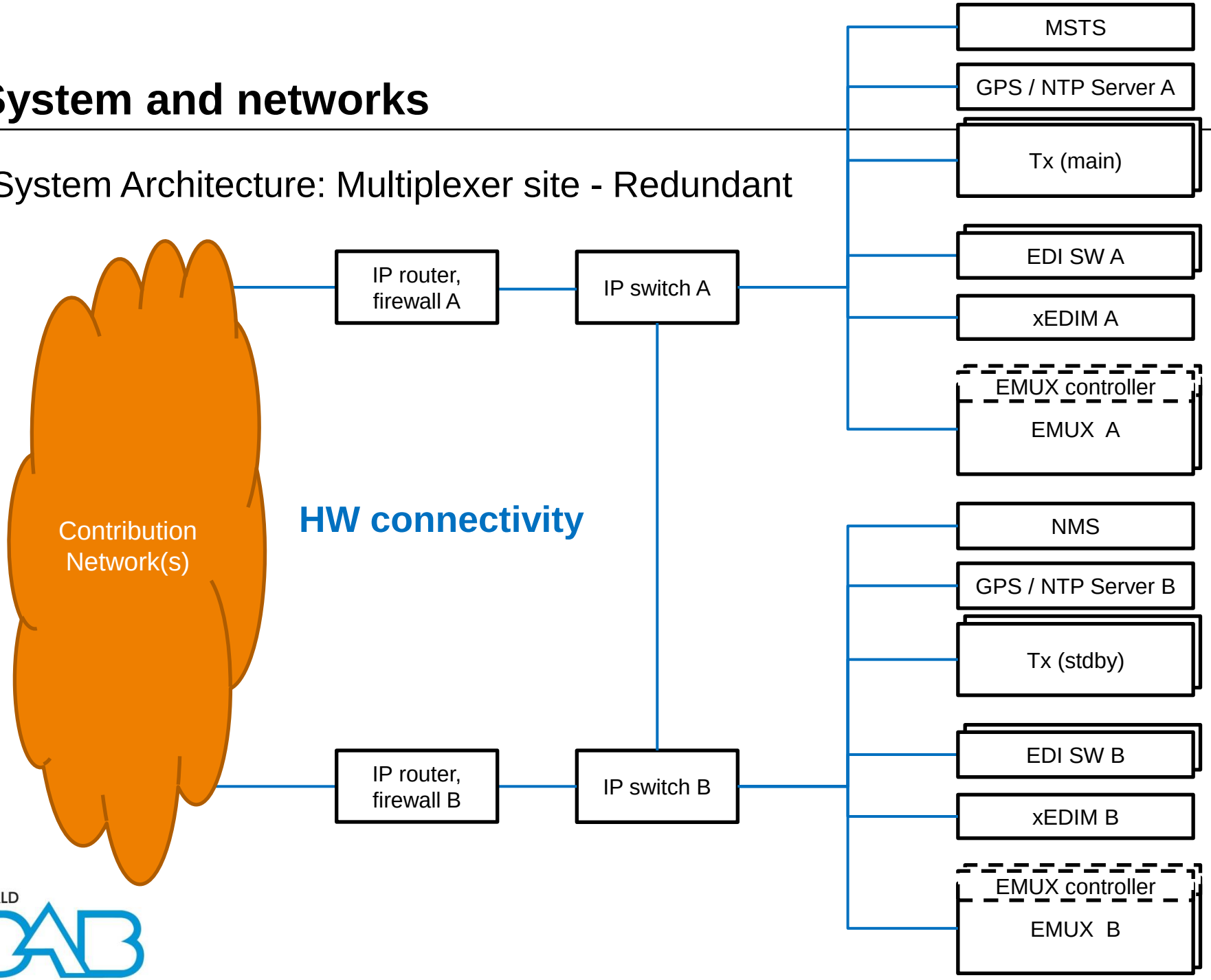
System and networks

System Architecture: Multiplexer site - Redundant



System and networks

System Architecture: Multiplexer site - Redundant



System and networks

Delay systems

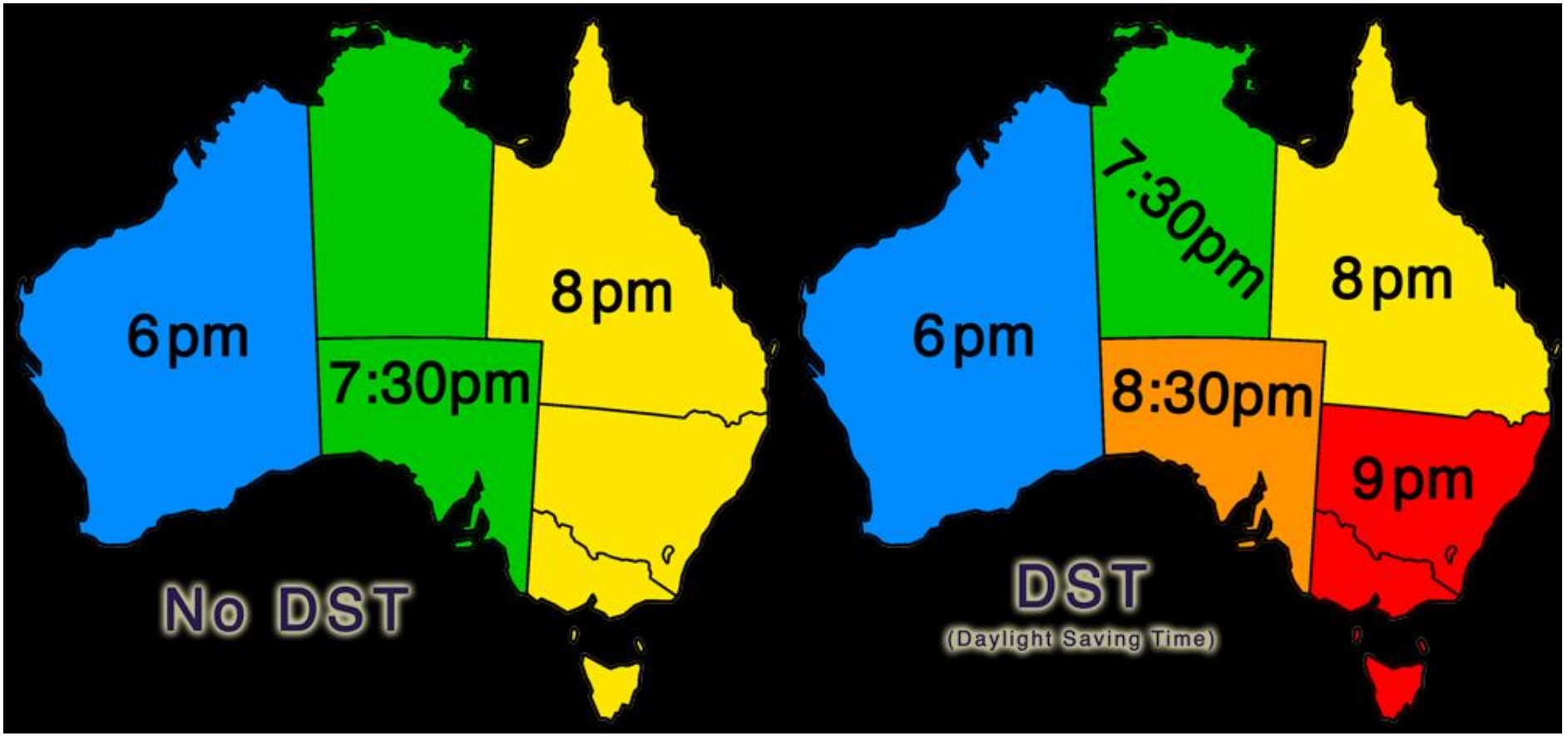
- Provide the ability to resynchronise content with the local time
- Delays can be minutes to hours
- Services / sub-channels are typically extracted from the ‘master’ or originating location, delayed and delivered to other ensembles

- The extraction and reinsertion can also be used to mix services across multiple equipment types
  - Interoperability is rarely used due to individual vender implementation idiosyncrasies

- Care is needed when making changes to ensure that services are synchronised

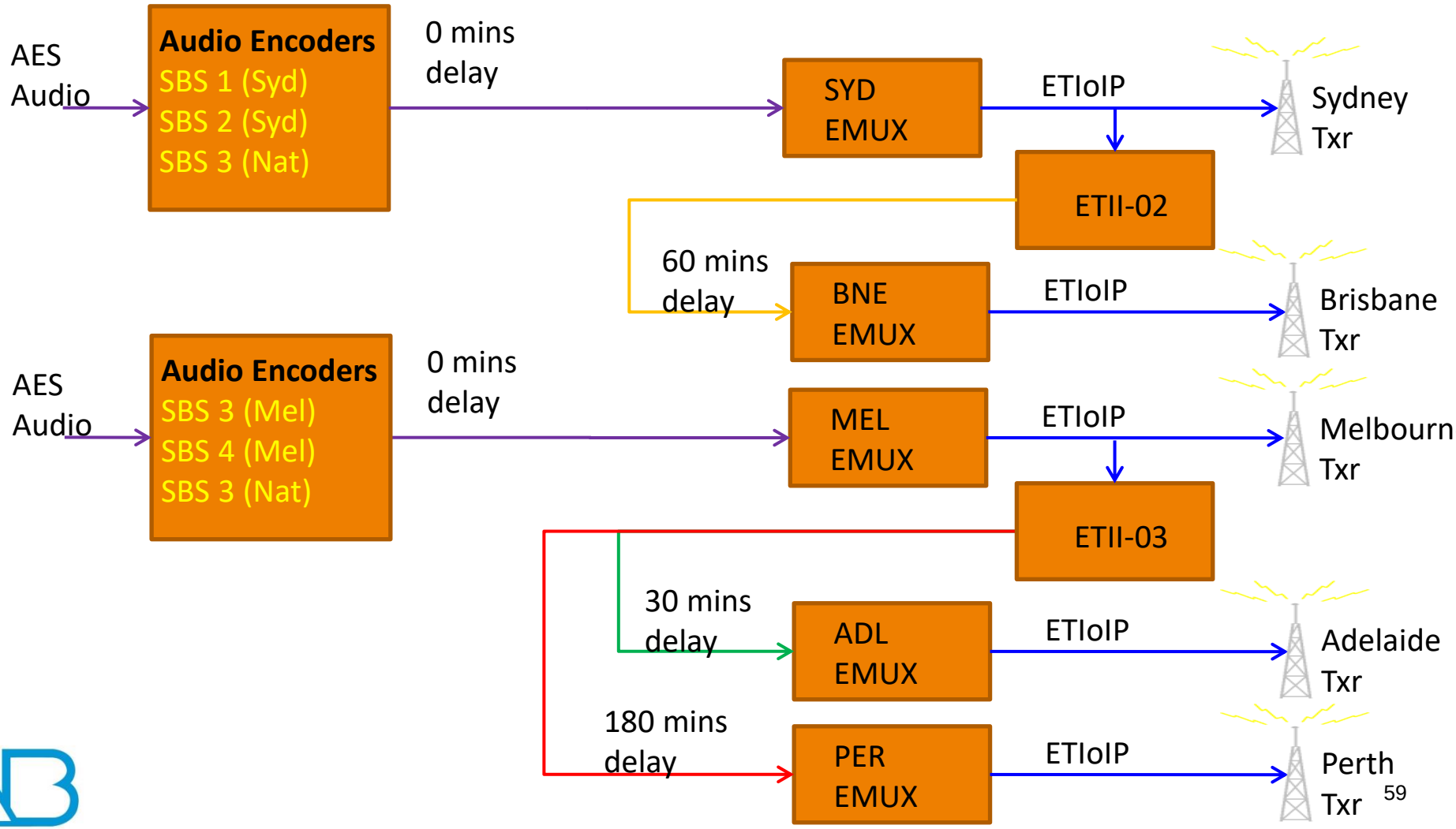
System and networks

Australian time zones



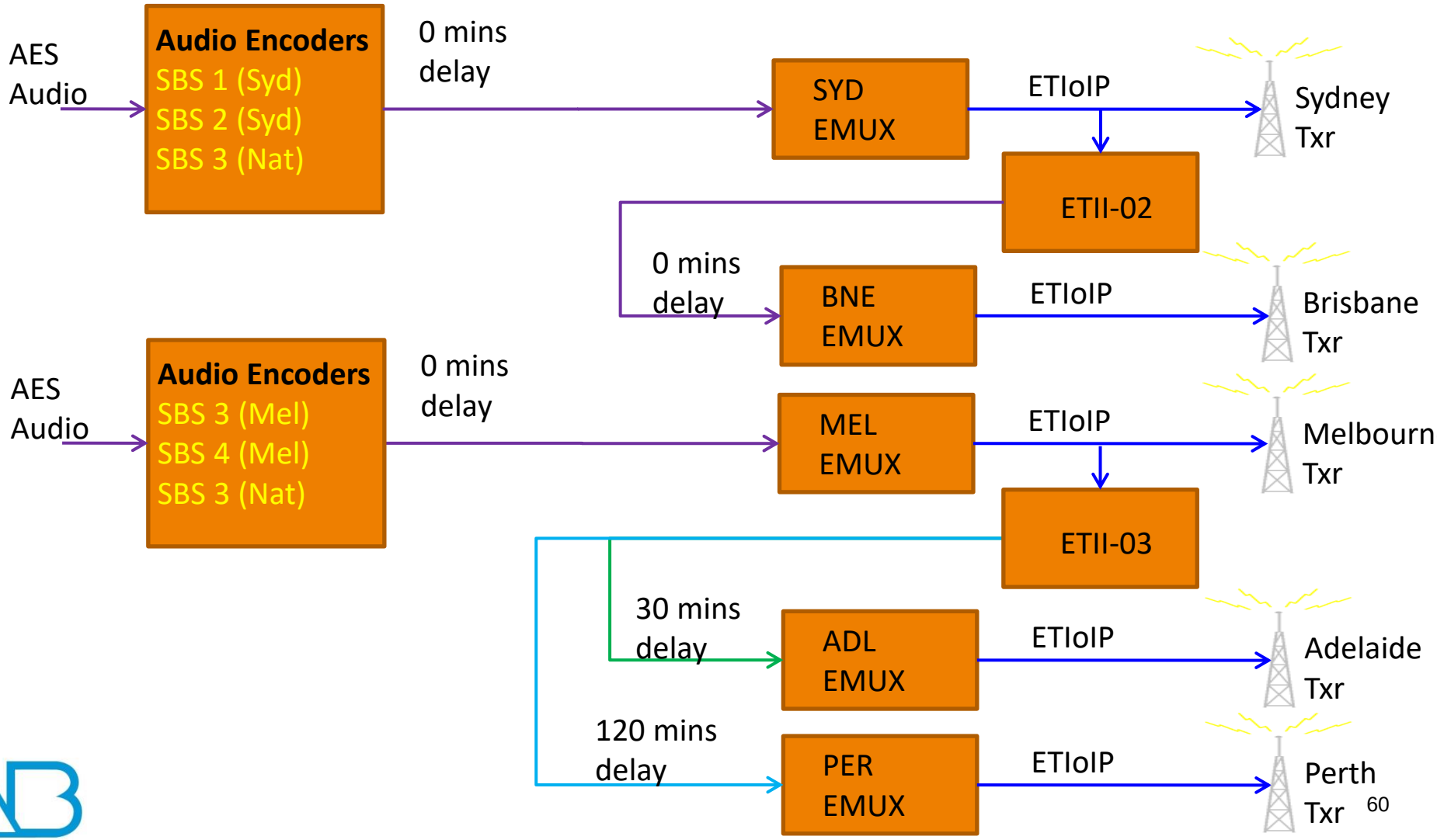
System and networks

SBS time delayed services - Summer



System and networks

SBS time delayed services - Winter



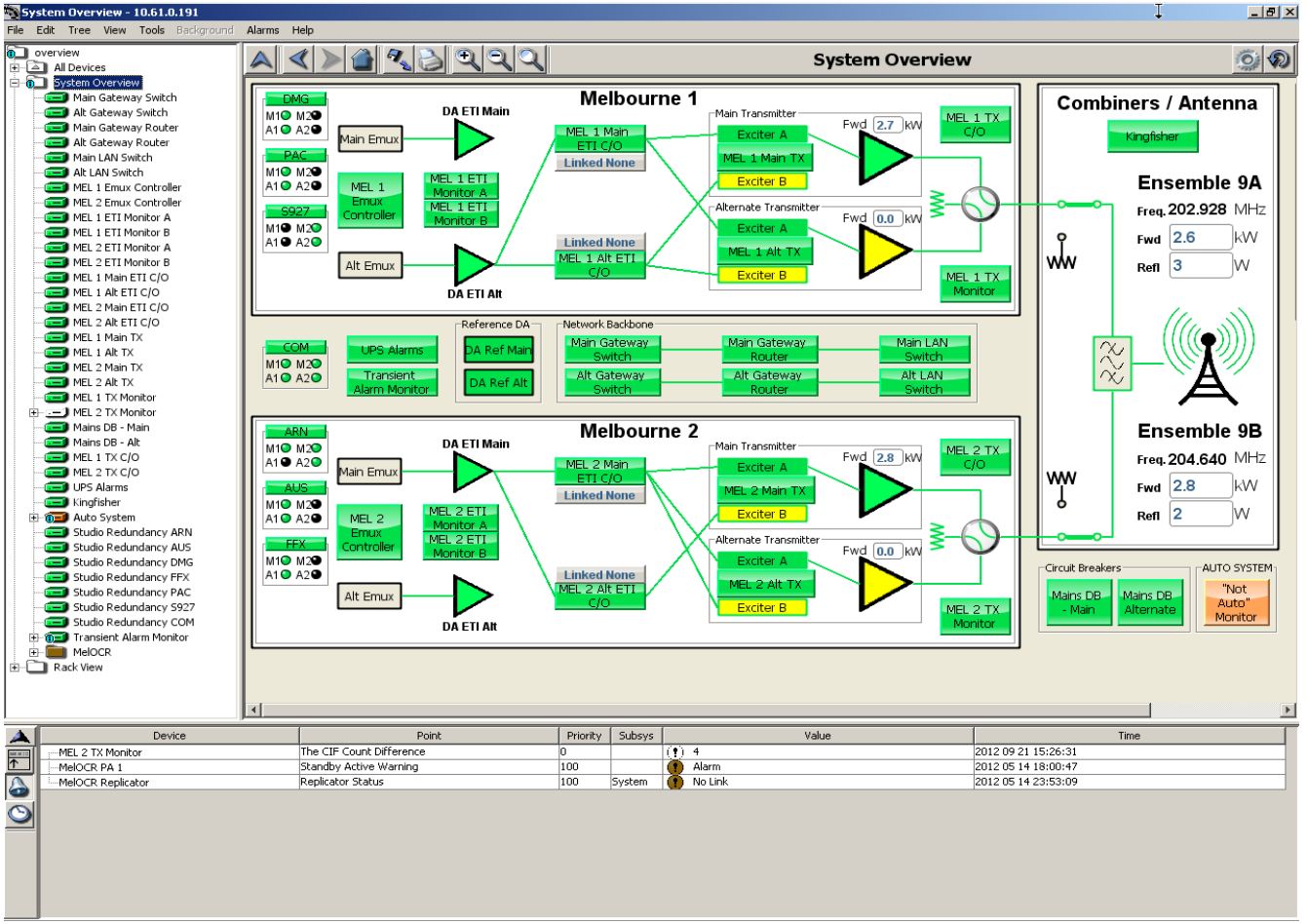
System and Networks

Network management

Network Management is essential for rapid fault detection and correction

Virtually all equipment now has SNMP fault reporting

Remote access via web interface allows best grade of service



System and networks

Examples

Summary

- DAB+ systems have many aspects
- Head-end system capabilities need to reflect the business requirements
  - Functionality
  - Suitability and fitness-for-purpose
  - Flexibility
  - Cost effectiveness
- Understand industry trends and factor them into contractual requirements
- Be careful of interoperability requirements considering multiple input and output systems

Thank you

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