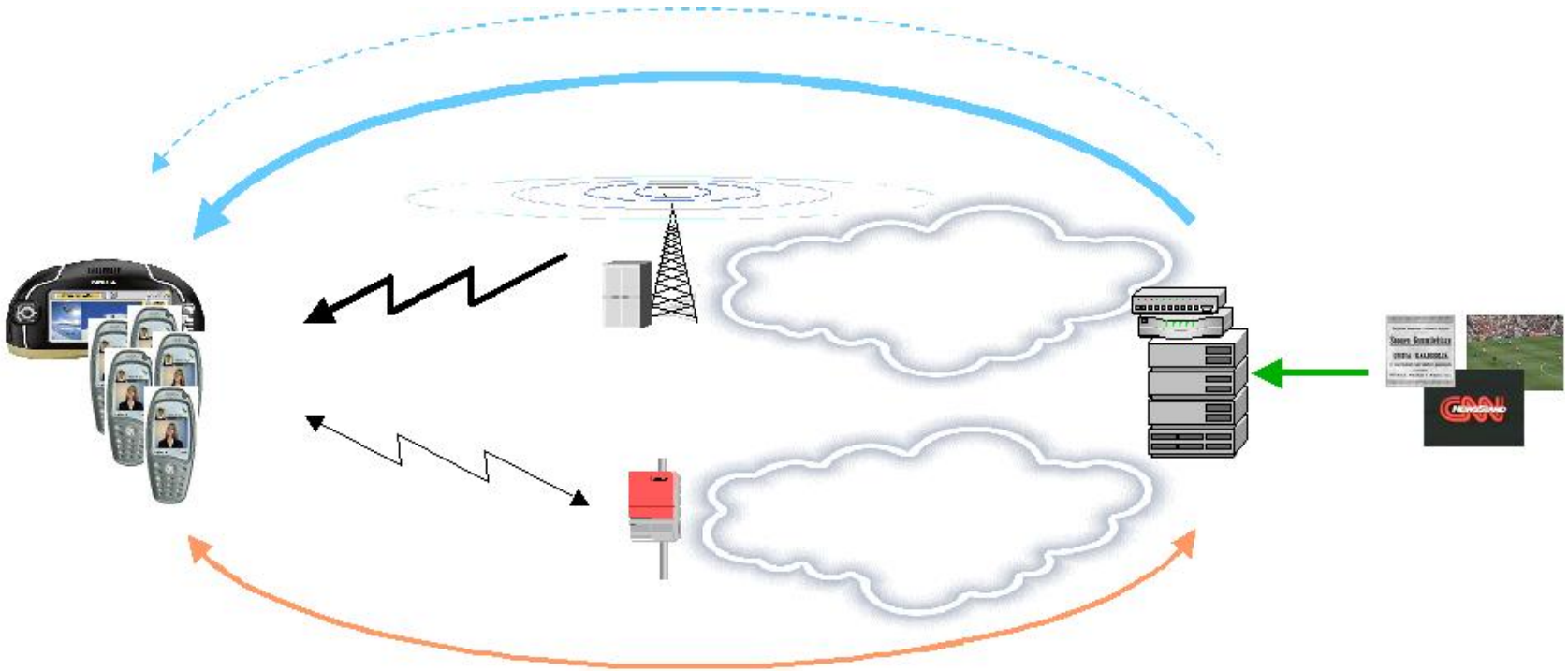
Advances in Mass Media Delivery to Mobiles



Advances in Mass Media Delivery to Mobiles

MIPS2004 Tutorial

Multimedia Interactive Protocols and Systems Workshop 2004

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http://mips2004.imag.fr/tutorials.php#tutorial2

Introduction (1/3)

Topic

- Mobile Mass Media (MMM) is both the content and delivery for widespread distribution
  - MMM is synonymous with broadcast TV & radio, newspapers and music distribution, and does not stop there
  - Principally unidirectional broadcast media
    - also termed IP datacast to mobiles
  - Potentially including associated procedures and interactive services

- This tutorial introduces Mobile Mass Media technology enablers…
- …and the standards-in-progress that will bring interoperability for the mass market

Introduction (2/3)

Motivation

- Mobile Mass Media is a convergence of broadcast media, the Internet and Mobile (cellular) communications
- The body of background technology & standardisation work now promises wide-spread global deployment of wireless mobile mass media over the next few years
- Great impact on an ordinary user's perception of the Internet and media
  - Expectations may be changed forever!!!
  - Broadcast-mobile-Internet glass walls shattered
- Successful services and applications will adapt to this new environment

- The work to enable this open and interoperable revolution is in progress
- The foundations are laid
- There are opportunities to
  - research technology enablers
  - optimise the end-to-end systems
  - develop applications and services
- And the present time is an excellent time to get involved!

Introduction (3/3)

Tutorial limits disclaimer

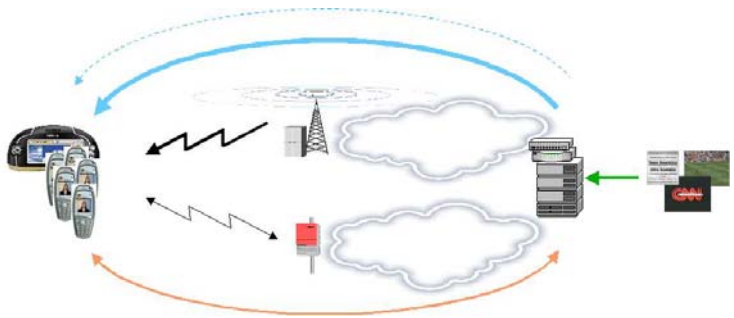
- Important details beyond the scope of this presentation include
  - Routing and core networks (including operator and Internet cores)
  - Radio and Link layers in general

Tutorial Structure

- Overview
  - Mobile Mass Media
  - Enabling Technologies
  - Standardisation Organizations activities
- Enabling Technologies
  - AV Streaming, file download, media discovery and more
- MBMS: Multimedia Broadcast Multicast Service
  - 3G MMM enhanced system
- IP Datacast over DVB-H
  - Mobile IP broadcast system
- Differences Between MMM Systems
- Summary and conclusion
  - Common, open and interoperable
  - Just the beginning

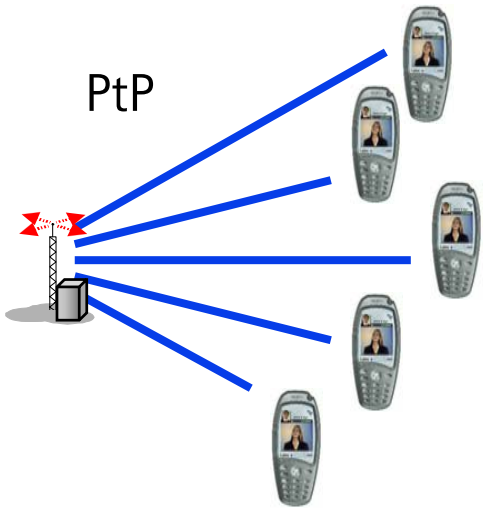
MMM Overview

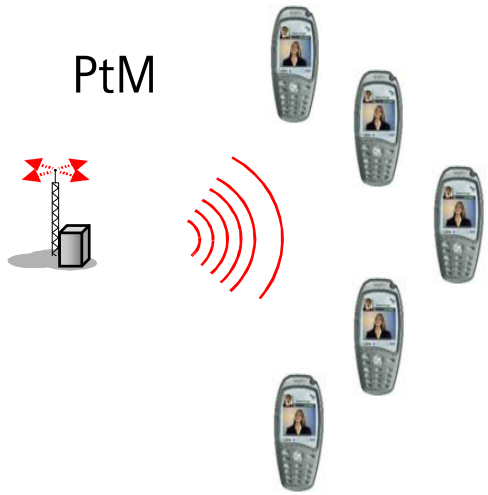
Mobile Mass Media Overview



MMM Motivation

- **Efficient delivery** of the same multimedia content to many people (devices in the same radio cell/area)
  - Lower the delivery cost for mobile content
  - Optimal for shared experience (mass media)
- User services based on content **download** and **streaming**
- MMM can generally be provided with cellular point-to-point (PtP) connections (or fixed Internet), but MMM is more efficient in cases where the same content is delivered to many recipients in a same cell





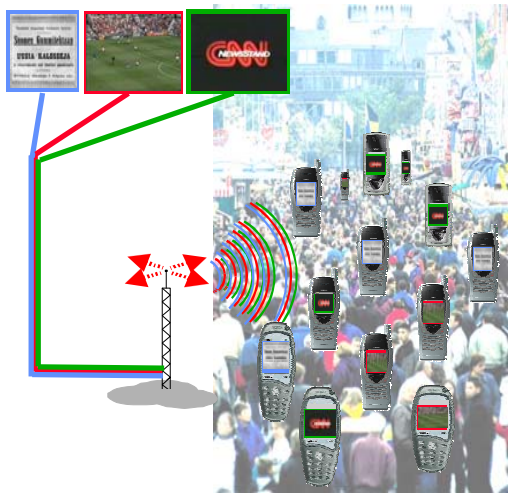
"No free lunch" -disclaimer:
There are constraints for using PtM instead of PtP delivery:
- Group (not individual) capability customized – datarates, minimum capabilities, etc. shared
- No streaming delivery guarantee. Service quality is heavily dependent on the underlying bearer
- Limited downloading delivery guarantees. When scaling up to large terminal groups significant delay (up to hours) could be normal for perfect delivery to 99.999% of terminals

Generic MMM Use Cases

- Generic use case: Any downloading/streaming service <u>with several users receiving the same content</u>

one-to-some

one-to-many



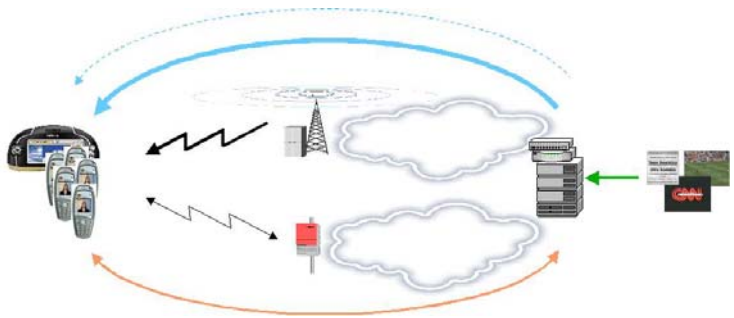
content delivery

- **Limitation:** MMM provides gains only if there are several recipients in individual radio cells! Size of audience and cell (and so radio/bearer specifics) has a significant impact on economic feasibility.
- Most frequently quoted use cases:
  - Multi-channel MobileTV
  - Digital football stadium

Making IP Multicast Easy

- Content delivery using IP Multicast is common to all MMM bearers
  - IETF standards (and work in progress) is heavily reused
  - IETF documents are a hub of interoperability
- Routing/switching is trivialised
  - Switched tunnels and operator administered back-bones are used
  - Last miles (radio links) are fully provisioned
  - The congestion and routing barriers to IP Multicast success on the Internet is not important to mobile mass media!
  - (MMM over the general Internet, e.g. fixed broadband o home, is not currently in scope)

Technology Overview

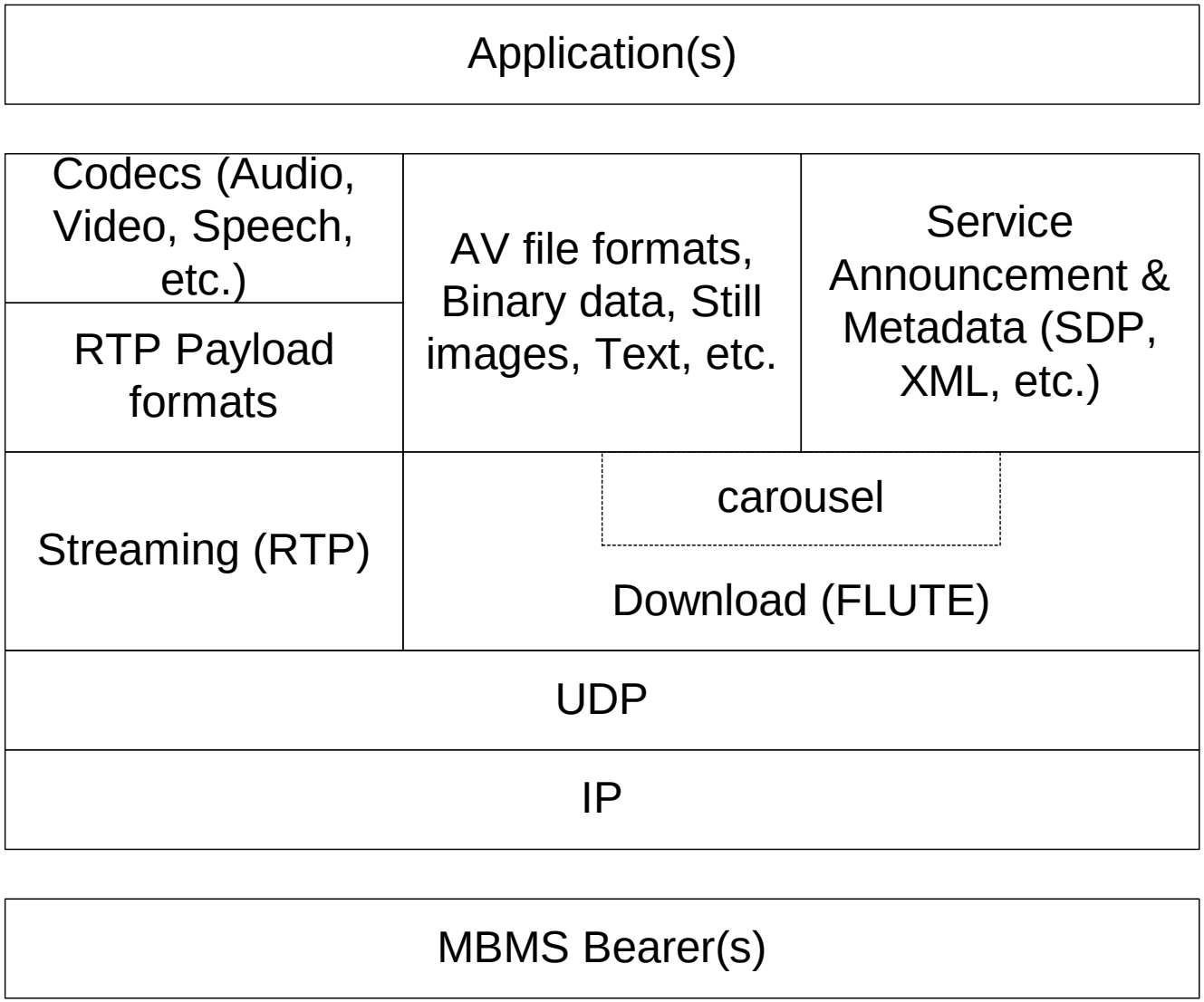


Multicast Point-to-Multipoint (PtM) Services

Streaming delivery:	RTP (audio, video, {streamed subtitle text})
Download delivery:	FLUTE (all discrete file types)
Service Announcement:	Download method (FLUTE) {Subscribe/notify (SIP)} {Fetch (HTTP)}
Carousel delivery:	{Specialised download delivery method}
Service Metadata:	Session Description –FLUTE & RTP sessions (SDP) User Service Description (XML) Associated Delivery Procedure Description (XML) {DVB's Electronic Service Guide many ESG-admin and ESG-attractor metadata fragments are still a work-in-progress}

Note, curly brackets {} indicate methods expected to only be used in only some of the MMM systems

(PtM) Protocol Stack



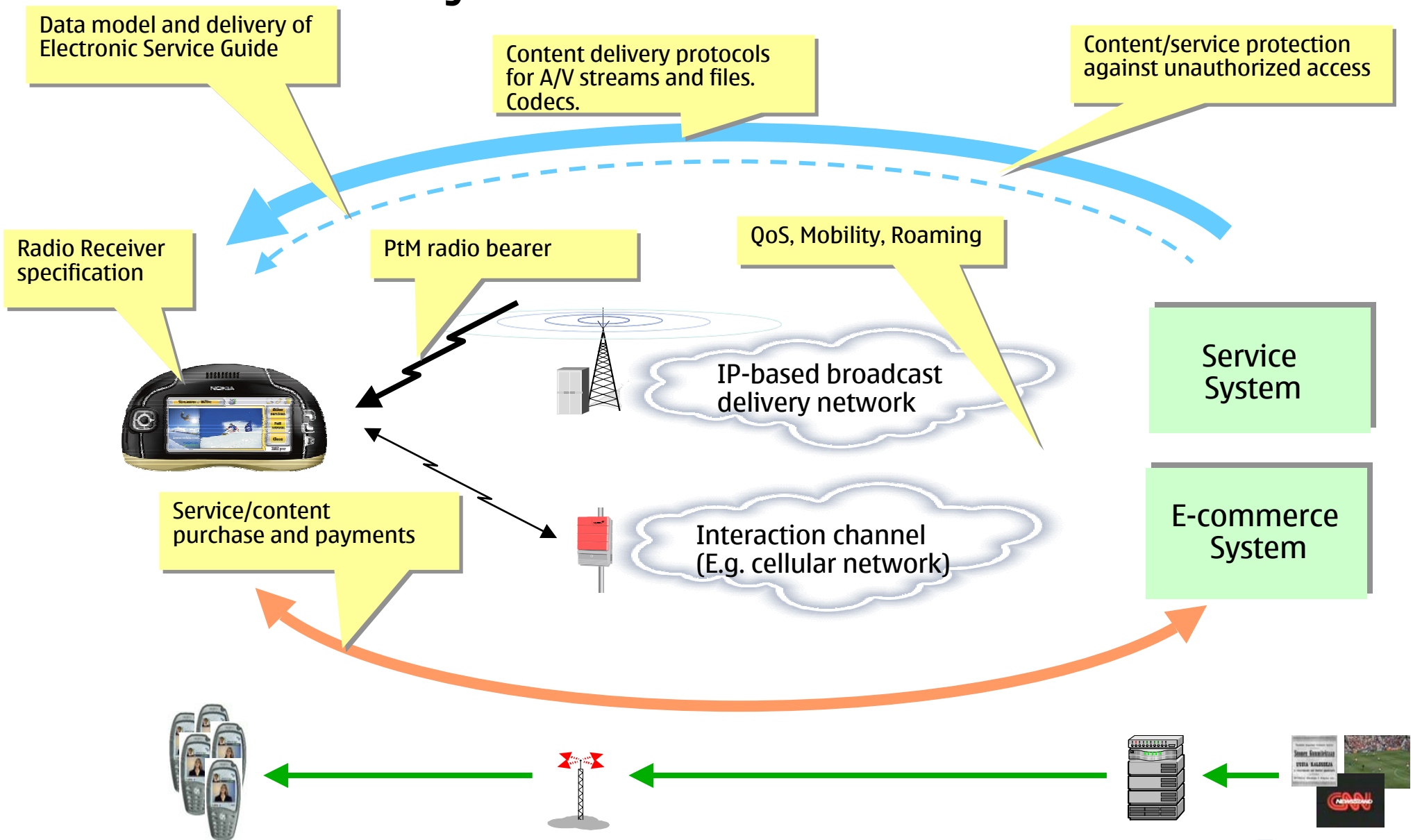
Note:

- RTP includes RTCP sender reports
- SRTP, IPsec (ESP) & download-encryption are to be included
- FEC for FLUTE & for RTP are expected to be included

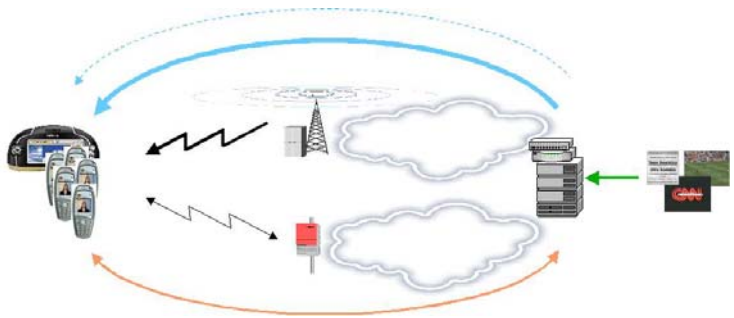
MMM Services Requiring (also) PtP Connectivity

Associated Delivery Procedures:	File repair (HTTP) <+ FLUTE for PtM response> Reception acknowledgement (HTTP)
Service Announcement:	Fetch (HTTP, {WAP}) {Subscribe/notify (SIP)}

System Technical Areas



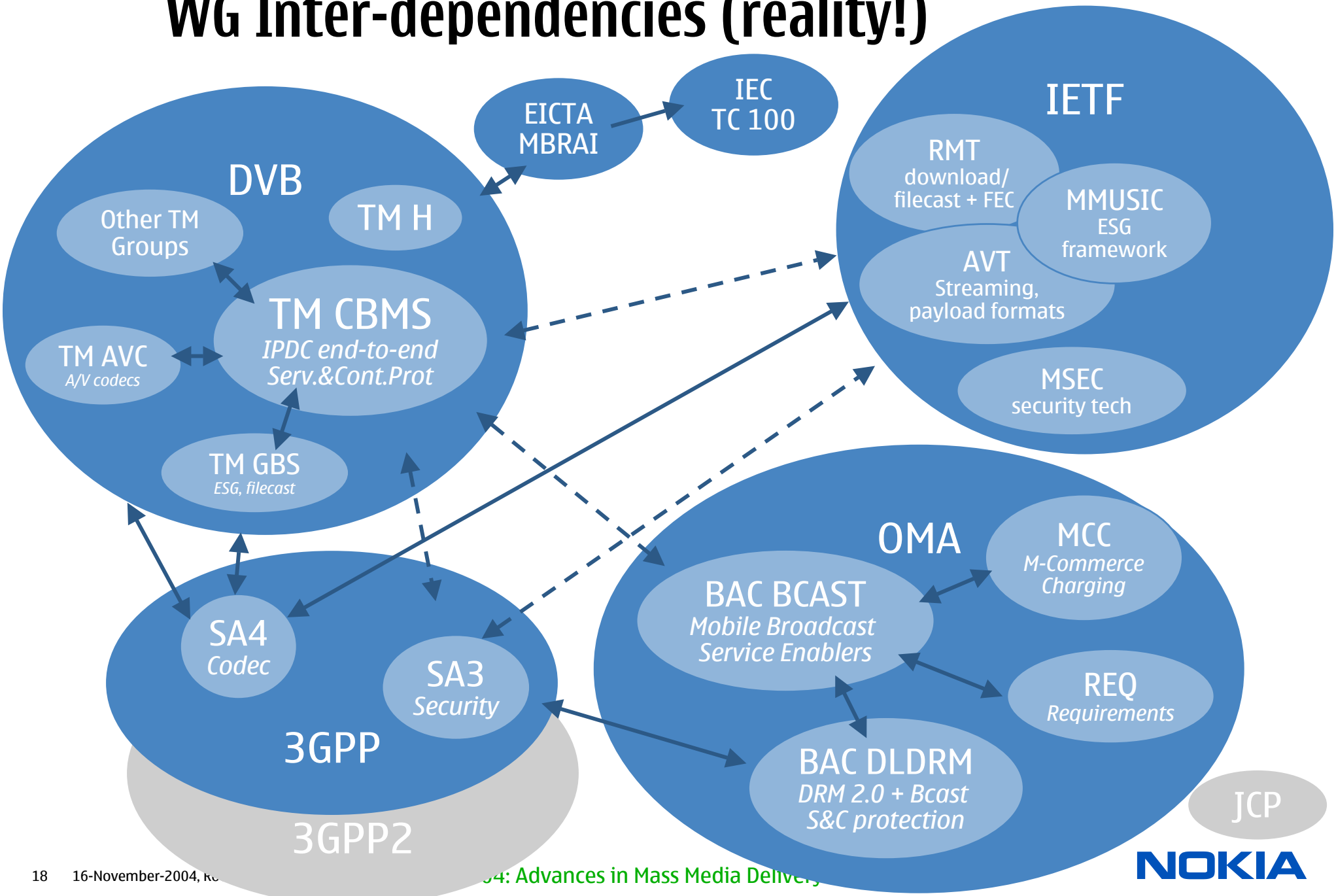
Standards Overview



Relevant Standards Organisations

- IETF
  - <Internet Engineering Task Force>
  - (note, no system wide activity)
- 3GPP
  - <3rd Generation Partnership Project>
  - MBMS: Multimedia Broadcast Multicast Service
- 3GPP2
  - <USA equivalent of 3GPP>
  - BCMCS: BroadCast MultiCast Service
- DVB
  - <Digital Video Broadcast (of ETSI)>
  - IP Datacast over DVB-H
- OMA
  - <Open Mobile Alliance>
  - BCAST: mobile BroadCAST services
  - Note the OMA Tao: “we steal with pride”

WG Inter-dependencies (reality!)



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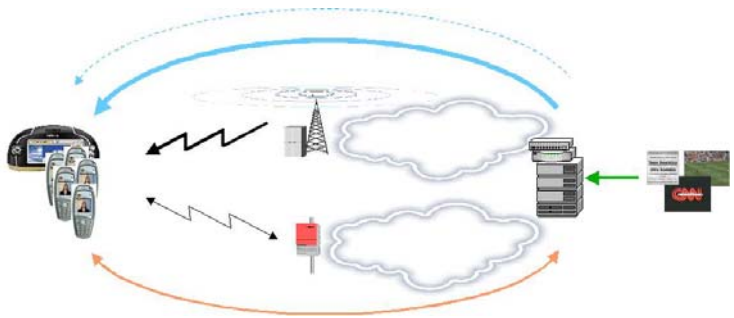
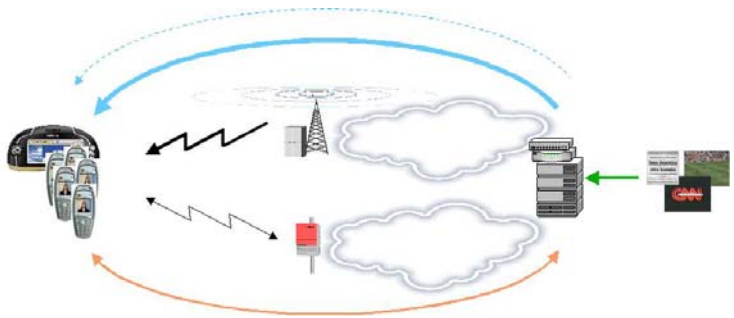
Multiple Standards Bodies; Multiple Roles

- Technical Enablers (with commonality) from:
  - IETF - PtM **transport and network layers**
  - 3GPP - PtM bearer (GERAN, UTRAN) and **IP service system**
  - DVB - PtM bearer (DVB-H) and **IP service system**
  - 3GPP2 - PtM bearer (CDMA2000)…
  - (Note, ISDB-T/Japan, T-DMB/Korea and DMB-T/China do not currently have momentum or ambition to become a global standard)
- Binding Interoperability
  - OMA - reuse bearer specifications from others
    - select which service system aspects to reuse
    - glue it all together + prove interoperability
- OMA/3GPP compliance is very important for “mobile world acceptance”
- Different standards organisations have different strengths and weaknesses:
  - IETF is tuned to very clear step-wise components and is notoriously difficult for system and architectural development
  - 3GPP handles system-wide approach and avoids complexity introduced by generalised solutions
  - DVB has excellent broadcast expertise though slows down drastically for contentious issues



Enabling Technologies

AV Streaming, file download, media discovery and more



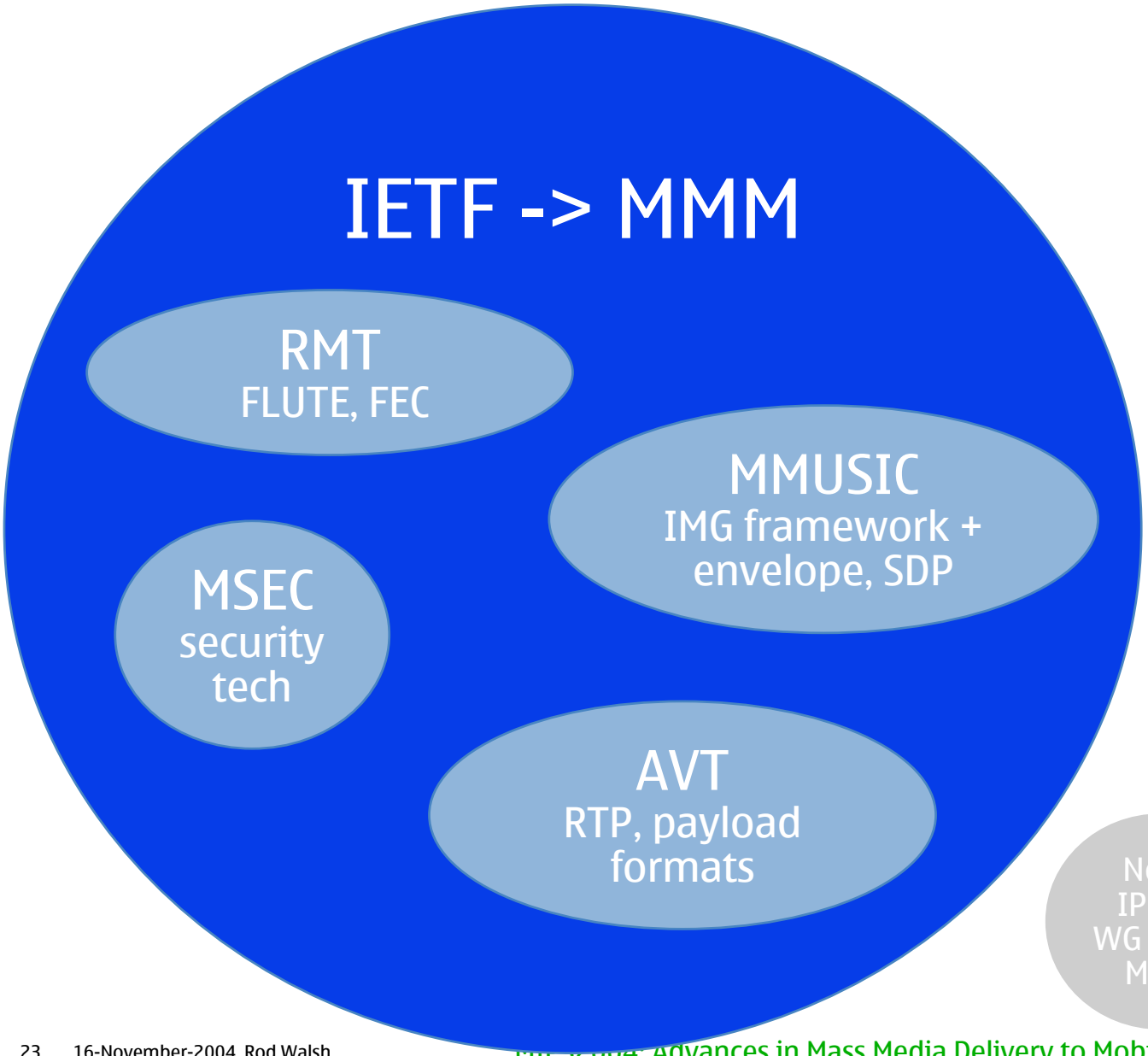
IETF Topics of Interest

- Streaming Media Transport - AVT
  - **RTP, RTP Payloads** (H.264, AAC+, AMR-WB+), [general FEC payload]
- Download Media Transport - RMT
  - **FLUTE**, [FEC]
- Media Guide Framework – MMUSIC
  - IMG Requirements, IMG Framework
- Service Announcements - MMUSIC+RMT
  - [muppet = flute application]
  - (SIP subscribe/notify)
- Metadata/Descriptions - MMUSIC
  - **FLUTE-SDP** (FLUTE Session Description) [3GPP compliant]
    - **source-filter** (ssm source address in SDP)
  - [baseline metadata model]
- Metadata Management - MMUSIC
  - **envelope** (metadata & transport independent) [3GPP compliant]
- Security
  - SRTP (Secure RTP) - AVT
  - ESP - IPsec
  - MIKEY - MSEC
  - SDP key and key management description - MMUSIC

Related To IMG (Internet Media Guides)

[indicates leadership also outside of the IETF]

IETF Working Groups of Interest



MMUSIC
Multiparty Multimedia Session Control WG

RMT
Reliable Multicast Transport WG

AVT
Audio Visual Technologies WG

MSEC
Multicast Security WG

IMG
Internet Media Guides

ESG
Electronic Service Guide (~IMG)

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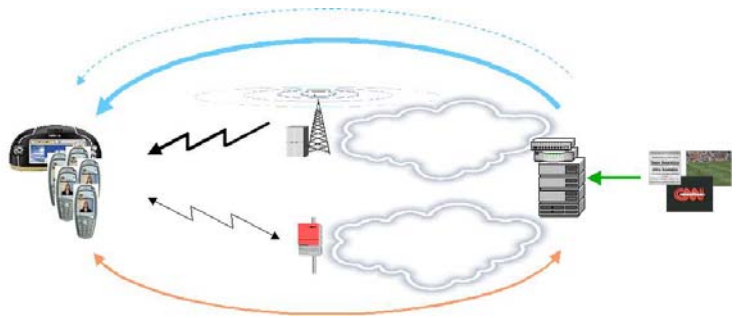
RTP, Payloads and Codecs

Enabling Technologies



RTP

- The Real-time Transport Protocol (RTP, RFC 3550) provides transport for streaming audio-visual (AV) media. For MMM, RTP operates over UDP/IP.
- Generally, Real-time Control Protocol (RTCP) sender reports (SRs) in the downlink are allowed for MMM systems, although receiver reports (RRs) in the uplink are not (i.e. they may use no more than 0% of the bandwidth)
- Each AV codec (or class of codec) requires a payload format to work with RTP

- RTP is very well known and has been established for some years so further streaming notes are only regarding new codecs for MMM.

(http://www.cs.tut.fi/kurssit/83390/syksy02/materials/Rod-apps.pdf includes a basic tutorial from 2002)

Video Media

- H.236 and MPEG-4 VSP are established video codecs
  - H.236 profile 3 is a recommended codec for 3GPP (release 5).
  - MPEG-4 VSP (Visual Simple Profile) and H.236 profile 3 compression performances are roughly equal (although MPEG-4 VSP performs better than H.236 baseline)
- The new MPEG-4 AVC Baseline (H.264/AVC, Advanced Video Coding) boast double the compression efficiency and is making head-way to becoming to only recommended MMM video codec

MPEG-4 AVC Baseline

- H.264 / MPEG-4 AVC:
  - ITU-T Rec. H.264 "Advanced Video Coding for Generic Audiovisual Services" & ISO/IEC 14496-10 (2003): "Information Technology - Generic Coding of moving pictures and associated audio - Part 10: Advanced Video Coding".
  - H.264 / MPEG-4 AVC standard provides superior compression efficiency / picture quality over the existing standards.
- 3GPP consortium accepted H.264 / MPEG-4 AVC as a recommended codec for PSS, MMS (and PS Conversational and 3G-324M) specifications of the 3GPP Release-6
- Proposed for DVB - IP Datacast:
  - To use MPEG-4 AVC Baseline (with constraint_set1_flag being equal to 1) of which decoding complexity is low enough to be implemented on today's low-end smartphones
  - Supported levels depends on the proposed capability class (see table above)
  - A large variety of different terminals with different resolution displays are receiving the services. To enable consistent user experience, the response document has recommendations for specific resolutions and frame rates for encoders/servers
  - To simplify the rendering systems, transmitted pictures shall consist of square (1:1 pixel aspect ratio) pixels in all the service categories.

H.264/AVC Compression Performance

Compared to H.263 and MPEG-4 Visual

- **Subjective tests** supervised by MPEG
  - Report provided in S4-030871 (S4-# indicates a 3GPP-SA4 document)
  - 3GPP's interest: H.264/AVC Baseline versus MPEG-4 Visual Simple Profile (VSP)
  - Realistic simulations conditions for MMS, PSS, and MBMS
  - Summary: AVC Baseline Profile achieved a **compression efficiency improvement of 2 times or greater** in 14 out of 18 statistically conclusive cases when compared to MPEG-4 VSP
- **Objective compression performance criteria** for new 3GPP Rel-6 video codec(s)
  - A new video codec has to provide the same objective quality (PSNR) with 50 % of the bitrate used by MPEG-4 VSP. (See details in S4-030712)
  - Results for H.264/AVC in S4-030739. **SA4 agreed that H.264/AVC Baseline Profile meets the objective performance criteria** (S4-030859).
- **Error resilience**
  - Needed in error-prone services, in particular conversational services.
  - **SA4 agreed that H.264/AVC Baseline Profile meets the qualification criteria**.
  - Some SA4 contributions (S4-040533, S4-040494) show that **H.264/AVC has at least the same error robustness as H.263 and MPEG-4 VSP**

H.264/AVC is a significant improvement to current 3GPP video codecs

- Note: H.263 Baseline (the default codec in 3GPP services) is a subset of MPEG-4 VSP and therefore provides inferior performance compared to MPEG-4 VSP. Thus, **the performance gap between H.264/AVC and H.263 Baseline is greater than in the results above**.
- Note: H.263 Profile 3 (a recommended codec in 3GPP services) provides similar features compared to MPEG-4 VSP and therefore **the compression performance of H.263 Profile 3 and MPEG-4 VSP is approximately equal**.

Audio Media

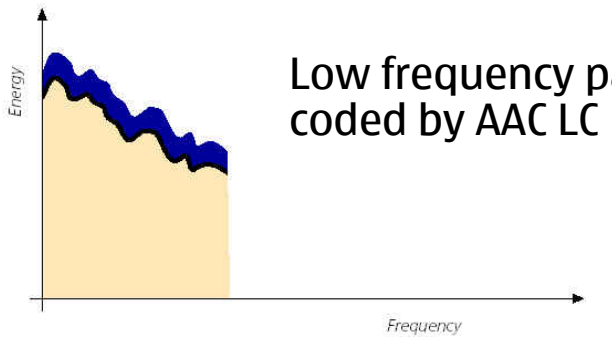
- Two audio codec are expected to be common to MMM systems;
  - Extended AMR-WB (AMR-WB+)
  - Enhanced AAC+ (e-AAC+, ”MPEG-4 HE AAC v2”)

Extended AMR-WB (AMR-WB+)

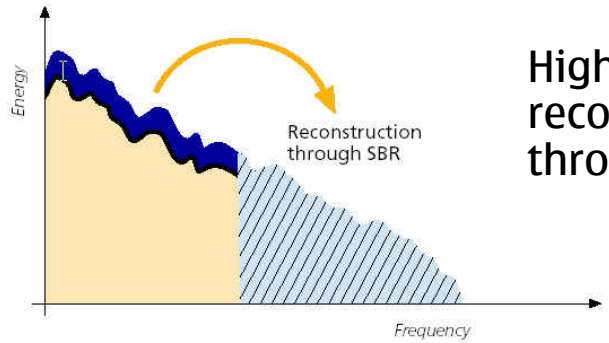
- The AMR-WB+ codec is specified in 3GPP TS 26.290:
  - Bit rate range from 14 to 48 kbps
  - Supports mono and stereo
  - AMR-WB modes ensure backwards compatibility
  - Codec providers consistent quality for different kind of mono and stereo content that can be expected to be used in the IPDC and MBMS services
  - Flexible codec control that improves the subjective quality of the AMR-WB+ codec with increased audio bandwidth especially in music content (see 3GPP S4-040065 and 3GPP S4-040439)
  - Complexity of AMR-WB+ is well below 3GPP design constraints (3GPP S4-030433, S4-040482)
- By Nokia, Ericsson, VoiceAge
- More information about AMR-WB+:
  - Licensing: http://www.voiceage.com/amrsite/tech_wbplus_terms.php
  - Demo samples: http://www.voiceage.com/amrsite/amr_samples.php
  - Executables: http://www.voiceage.com/amrsite/tech_wbplus_download.php

Enhanced AAC+ ("MPEG-4 HE AAC v2")

- aacPlus =AAC+ = MPEG-4 AAC HE (High Efficiency profile)
  = MPEG-4 AAC LC (Low Complexity) + SBR (Spectral Band Replication):
  - SBR calculates a parametric description of the high audio frequencies



Low frequency part, coded by AAC LC



High frequency reconstruction through SBR

- Enhanced AAC+ (e-AAC+) = AAC+ and Parametric Stereo (PS), extends usability to lower bit rates (below 32 kbps)
- Compatibility:
  - e-AAC+ can decode both AAC+ and AAC LC bit streams
  - AAC+ can decode AAC LC bit stream. If AAC+ decodes e-AAC+ bit stream then output is mono in the audio frames where PS-tool has been used.
  - AAC LC can decode only AAC LC encoded part of the AAC+ or e-AAC+ bit streams => the audio bandwidth reduces to half compared to AAC+ (and part of the streamed bit rate would not be decoded + impact of PS-part)
- Complexity of e-AAC+ is below 3GPP design constraints
- AAC LC, AAC+ and e-AAC+ supports mono, stereo, 5.1 etc (up to 48 channels)
- More information: http://www.codingtechnologies.com

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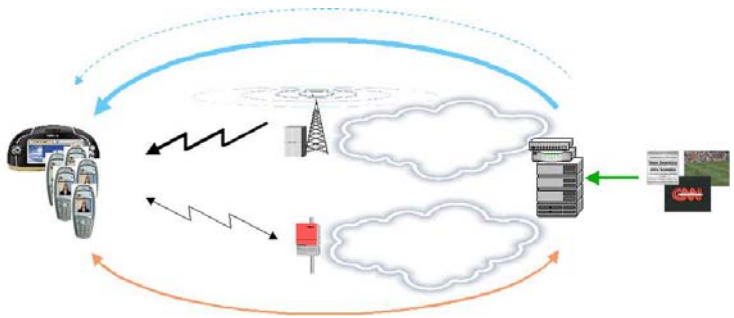
FLUTE and Related Technologies

Enabling Technologies



FLUTE

- FLUTE Introduction
- How FLUTE Works
  - Transport objects, segmentation and FEC
  - FDT Instances
  - Transport of objects
- Additional Information
  - Some FLUTE Session Variations
  - An Example Packet Header with File Data Payload
  - Example Packet Header with FDT Instance Payload
- Implementations, interoperability and open source
- Additional Notes on FEC and CC

FLUTE Introduction

FLUTE

RFC 3926 - File Delivery over Unidirectional Transport

FLUTE is a protocol for the unidirectional delivery of files over the Internet, which is particularly suited to multicast networks. The specification builds on Asynchronous Layered Coding (ALC), the base protocol designed for massively scalable multicast distribution.

Purpose:

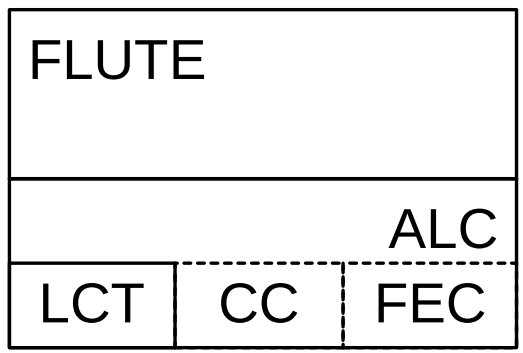
To deliver files, over unidirectional and multicast networks

Inheritance from RMT (Reliable Multicast Transport WG):

Based on ALC & LCT, but _fully_ specified

Plug-in FEC (Forward Error Correction)

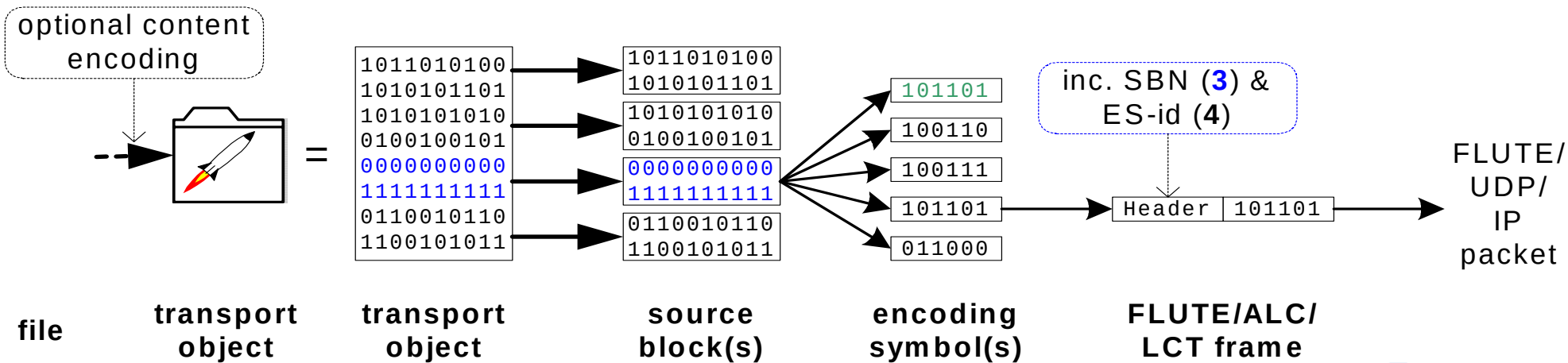
Plug-in Congestion Control (CC)



How FLUTE Works (1/3)

- Flute sessions run over one (or more) SSM or ASM channels
- Files are delivered as transport objects, with optional content encoding (e.g. gzip). A unique instance of a transport object is allocated a unique transport object identifier (TOI) for that session
- FEC is a 'plug-in' building block for reliability and also provides file segmentation into source blocks and (after optional FEC encoding) encoding symbols. Each encoding symbol is uniquely identified, for a given TOI, by the {Source Block Number (SBN), Encoding Symbol Id (ESI)} pair.
- 1 or more source block per file, and zero or more symbols per packet payload are allowed

Segmentation & FEC



How FLUTE Works (2/3)

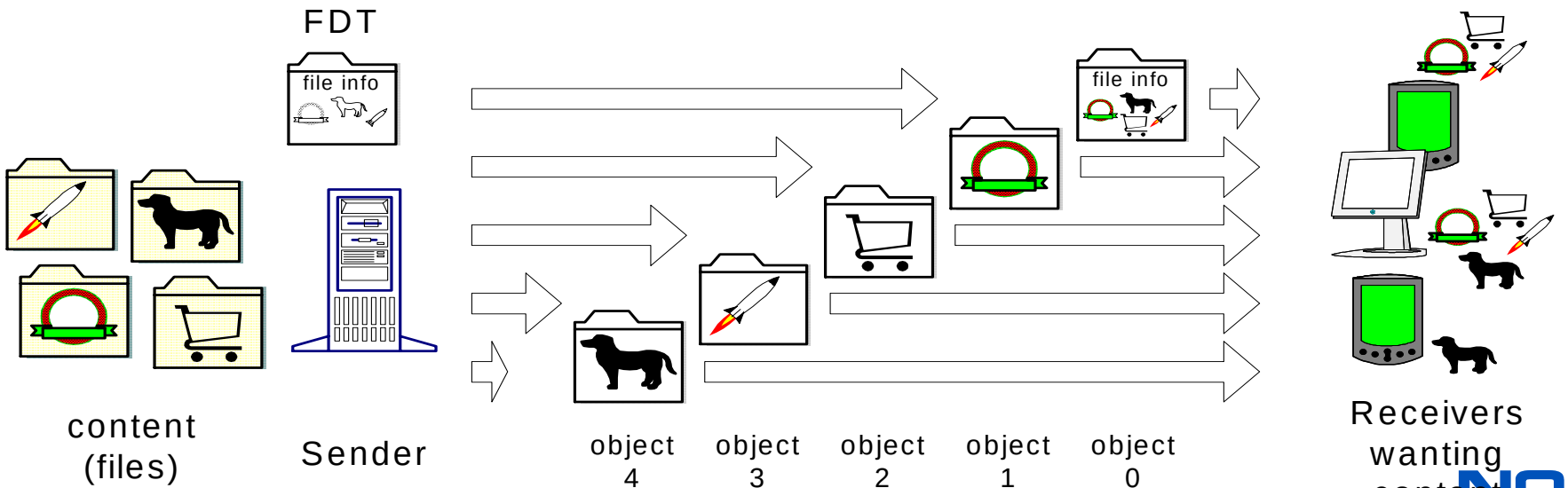
- Instances of the File Description Table (FDT) give the necessary parameters to identify, locate and restore the files (in addition to inherited ALC protocol headers). FDT Instances can describe one/many files.
- An example FDT Instance:

```
<?xml version="1.0" encoding="UTF-8"?>
<FDT-Instance xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:fl="http://www.example.com/flute"
xsi:schemaLocation="http://www.example.com/flute-fdt.xsd"
Expires="2890842807">
        <File
                Content-Location="www.example.com/menu/tracklist.html"
                TOI="1"
                Content-Type="text/html"/>
        <File
                Content-Location="www.example.com/tracks/track1.mp3"
                TOI="2"
                Content-Length="6100"
                Content-Type="audio/mp3"
                Content-Encoding="gzip"
                Content-MD5="Eth76GlkJU45sghK"
                Some-Private-Extension-Tag="abc123"/>
</FDT-Instance>
```

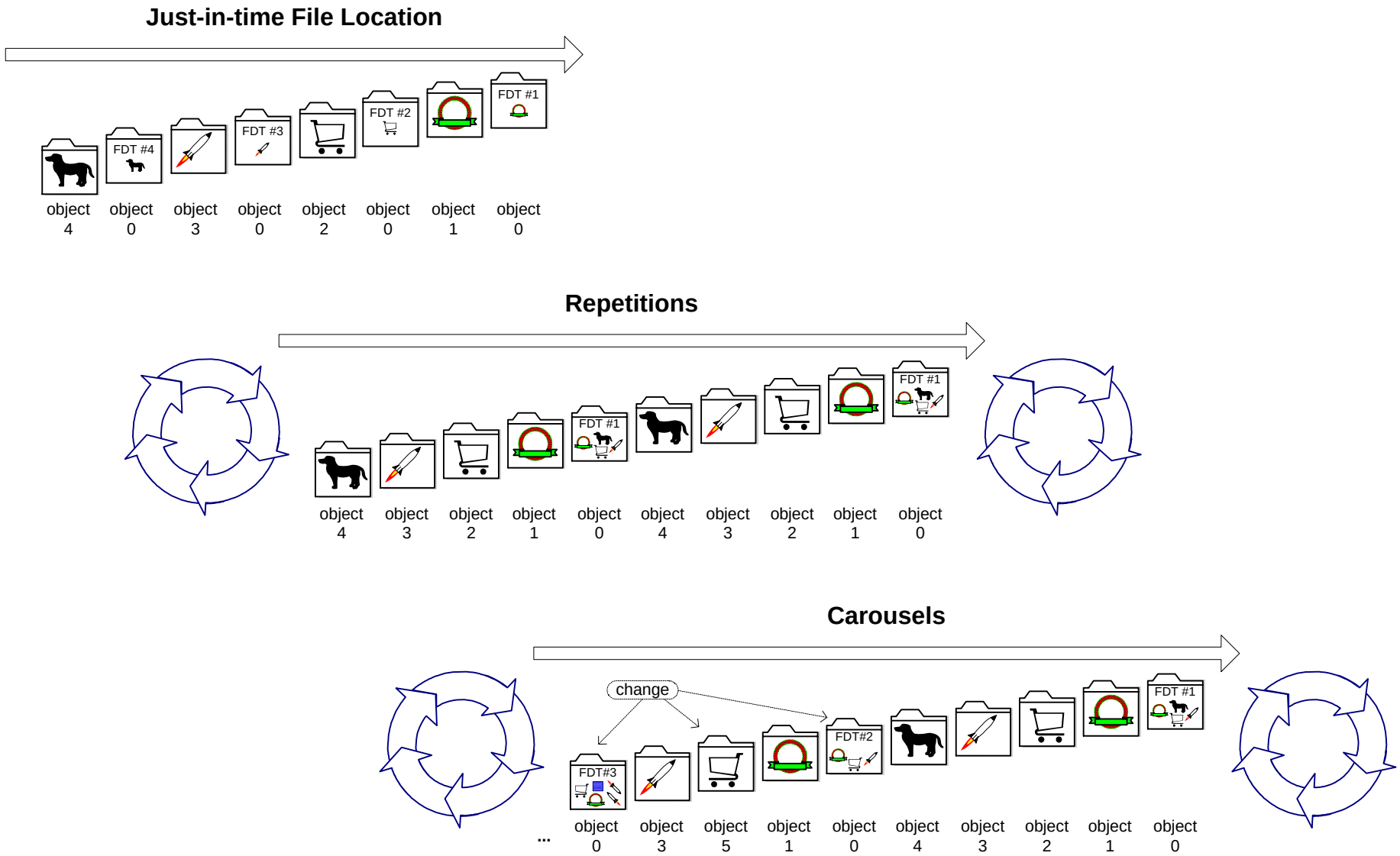
How FLUTE Works (3/3)

- FDT Instances may contain all or part of the file list (and parameters) for the FLUTE session.
- FLUTE sessions may be started without complete knowledge of their content (requiring FDT Instances to progressively “announce” file parameters during the session)
- Frequency and repetition (if any) of FDT Instance data is not specified
- A simple example of 4 files delivered by a session which are all described by one FDT Instance, and that FDT Instance is delivered before the set of files…

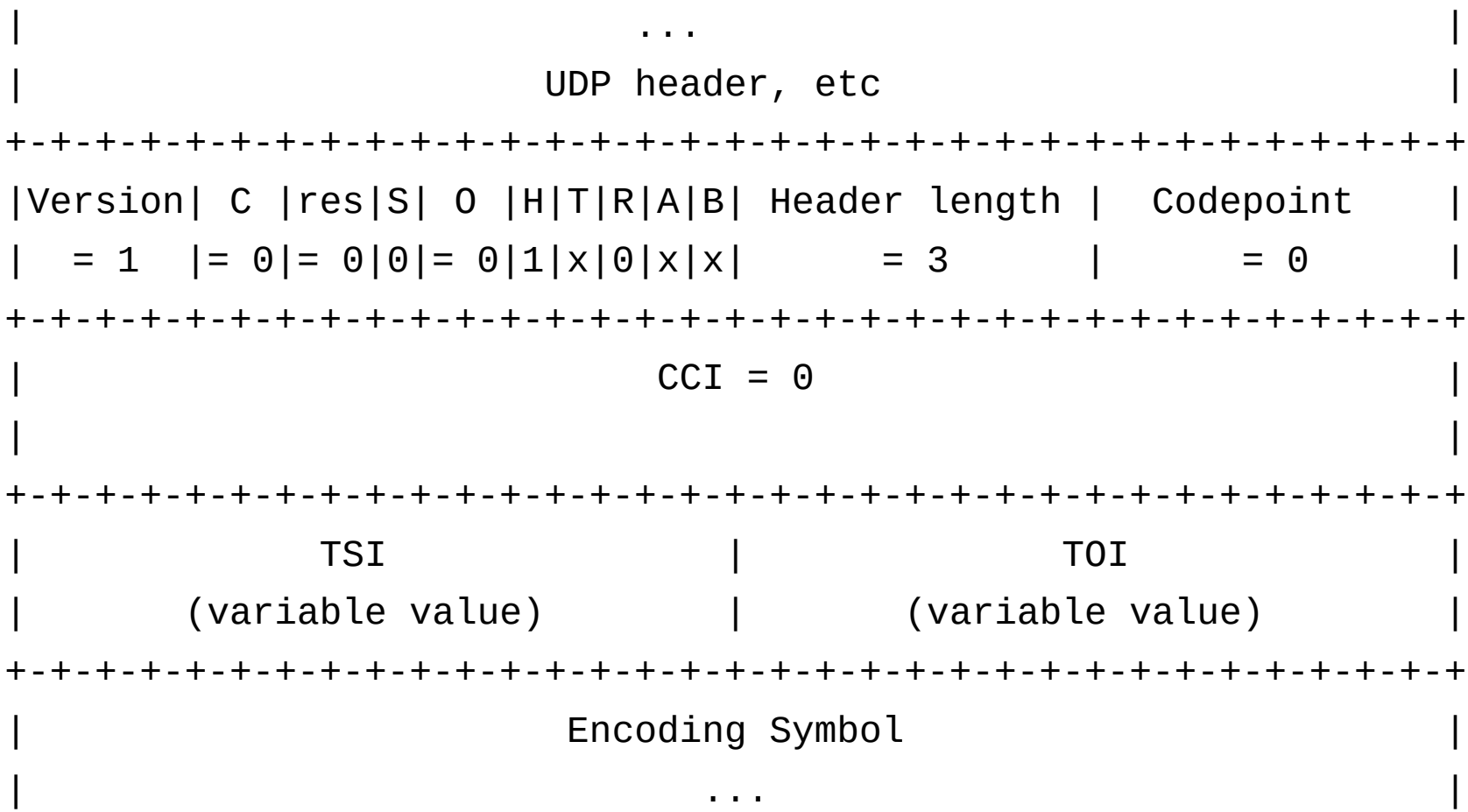
One Shot Delivery with a Single FDT Instance



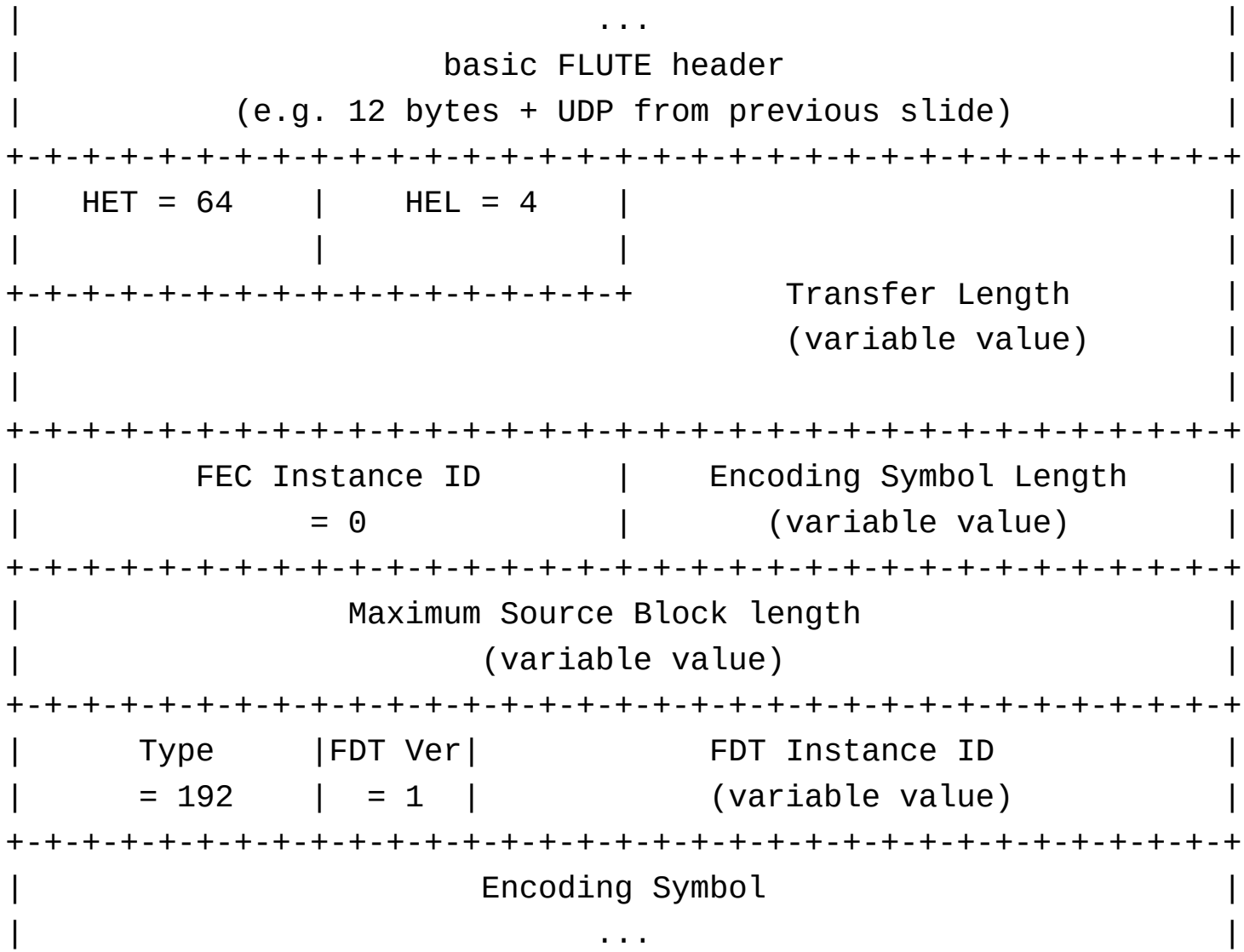
Some Session FLUTE Variations



An Example Packet Header with File Data Payload

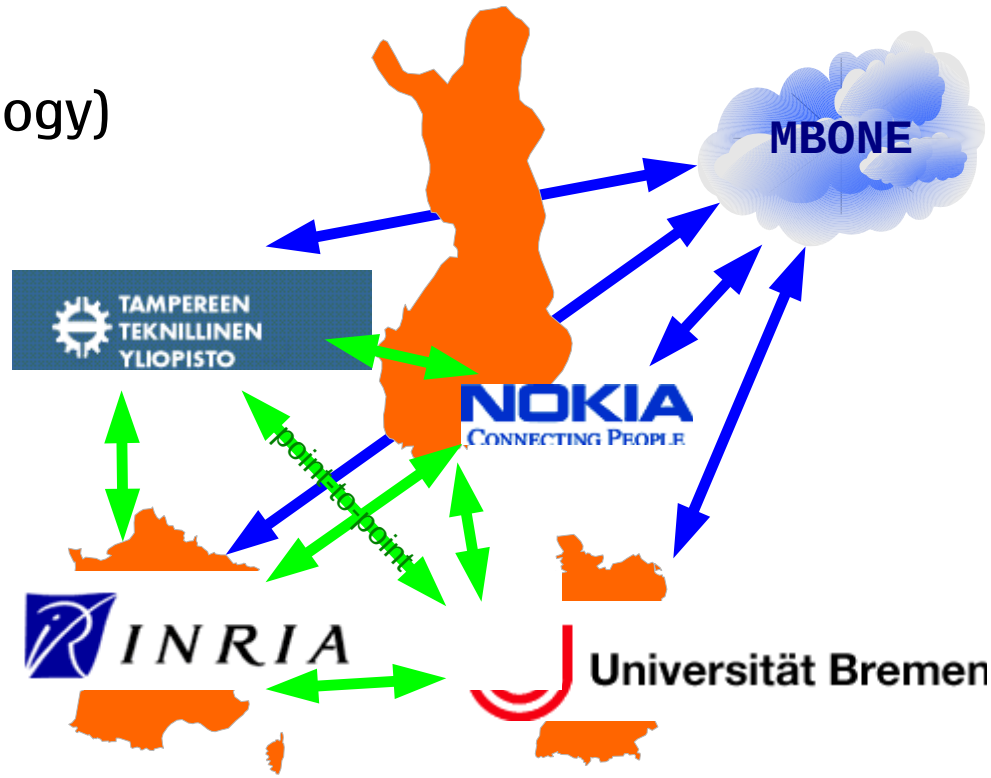


Example Packet Header with FDT Instance Payload



Interoperability between 4 Genetically Different FLUTEs

- INRIA
  - www.inrialpes.fr/planete/people/roca/mcl/mcl.html
  - vincent.roca@inrialpes.fr
- TUT (Tampere University of Technology)
  - www.atm.tut.fi/mad/
  - jani.peltotalo@tut.fi
- Nokia
  - proprietry
  - rod.walsh@nokia.com
- University of Bremen
  - www.uni-bremen.de/
  - jo@tzi.uni-bremen.de



- Tested against each other one-to-many, many-to-many

- Also Digital Fountain implementation exists (proprietary, already partly productised)

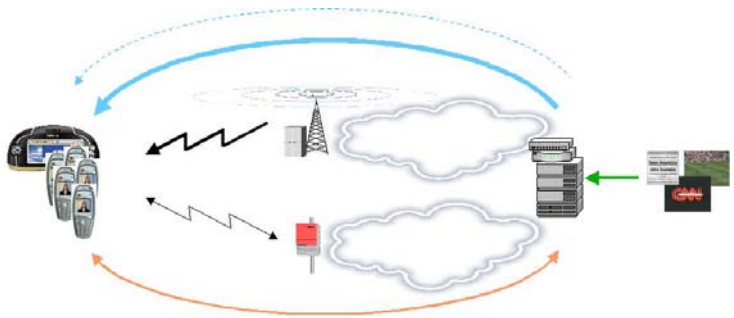
Additional Notes on FEC and CC

- Congestion Control (CC) is an essential part of the RMT WG work to ensure that reliable multicast transport will co-exist with existing (TCP) traffic on the public Internet without problems (and certainly without meltdown)
- Publication of CC blocks (i.e. RFC) is essential to the standardisation progress of many of the RMT RFCs
- However, transport layer CC is not important to unidirectional data over the fully-provisioned switched core networks as used in the MMM systems considered here

- Forward Error Correction Codes can be a very efficient way of reducing data loss using data redundancy and mathematical recovery of lost packet data
- Several FEC code are well known, such as varients of Reed-Solomon (R-S), Low Density Parity Check (LDPC) and Raptor codes.
- To date, only the “compact no code FEC” (null-fec) scheme (RFC 3695) has been accepted into 3GPP and DVB MMM standards.

Internet Media Guides (IMG)

Enabling Technologies



IMG Introduction

- Internet Media Guides (IMGs) provide and deliver structured collections of multimedia descriptions expressed using SDP, XML (e.g. SDPng) or other description formats
- They describe sets of multimedia services (e.g. television program schedules, content delivery schedules) and refer to other networked resources including web pages
- IMGs provide an envelope for metadata formats and session descriptions defined elsewhere which facilitates structuring, versioning, referencing, distributing, and maintaining (caching, updating) such information
- IMG metadata may be delivered to a potentially large audience, who use it to join a subset of the sessions described, and who may need to be notified of changes to the IMG metadata
- The IMG framework provide for distributing IMG metadata in various different ways is needed to accommodate the needs of different audiences: For traditional broadcast-style scenarios, multicast-based (push) distribution of IMG metadata needs to be supported. Where no multicast is available, unicast-based push is required too

A Simple Hierarchical Media Guide

- Root
  - News
    - BBCworld
    - CNN
  - Entertainment
    - Music
      - Record shop
        - Music downloads
          - Top 20 hits today at 20:00-20:30
            - Song1.mp3
            - Song2.mp3

category

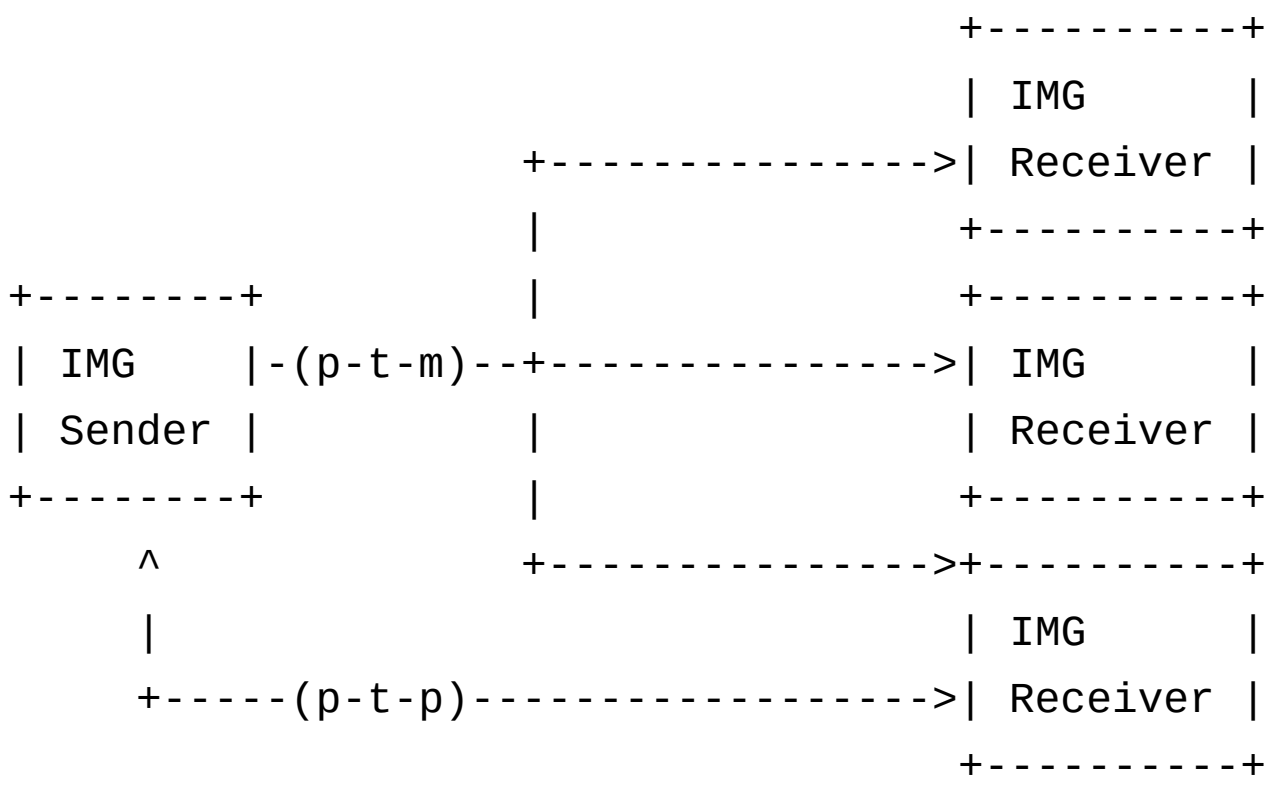
service portal

service

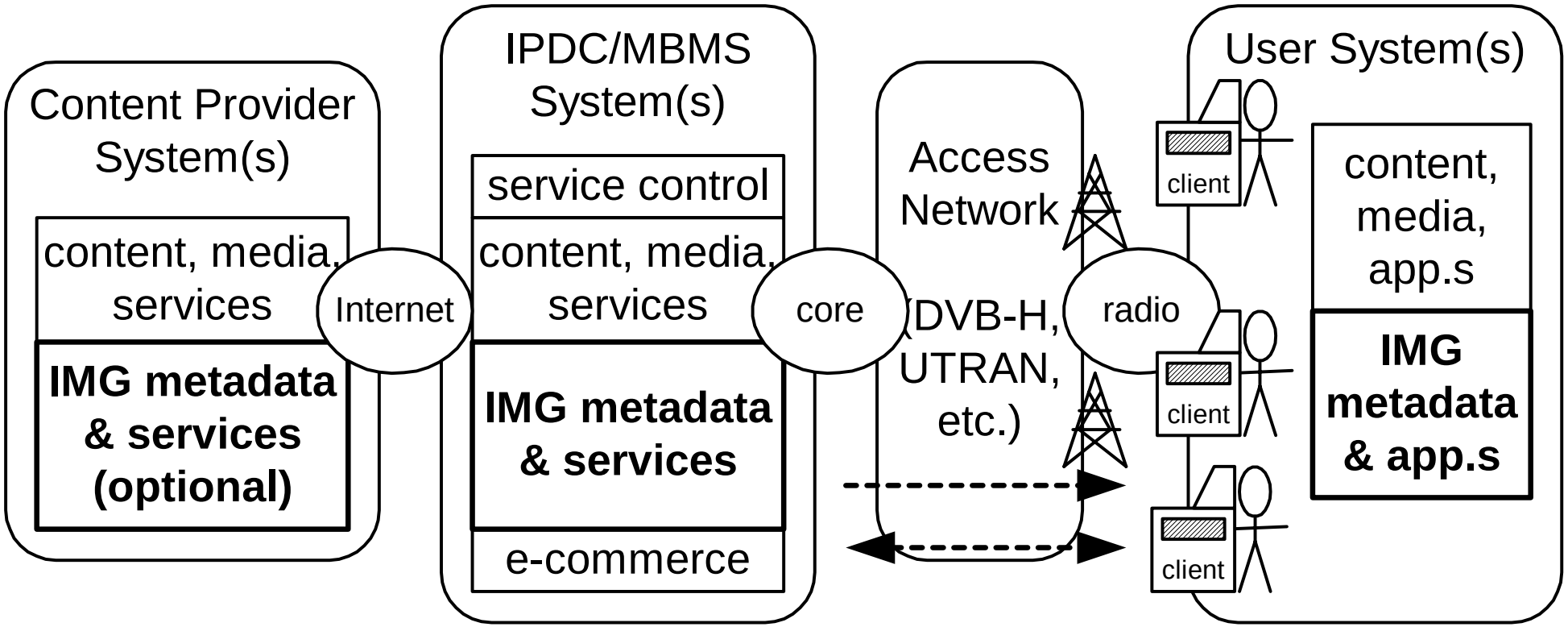
session

service item

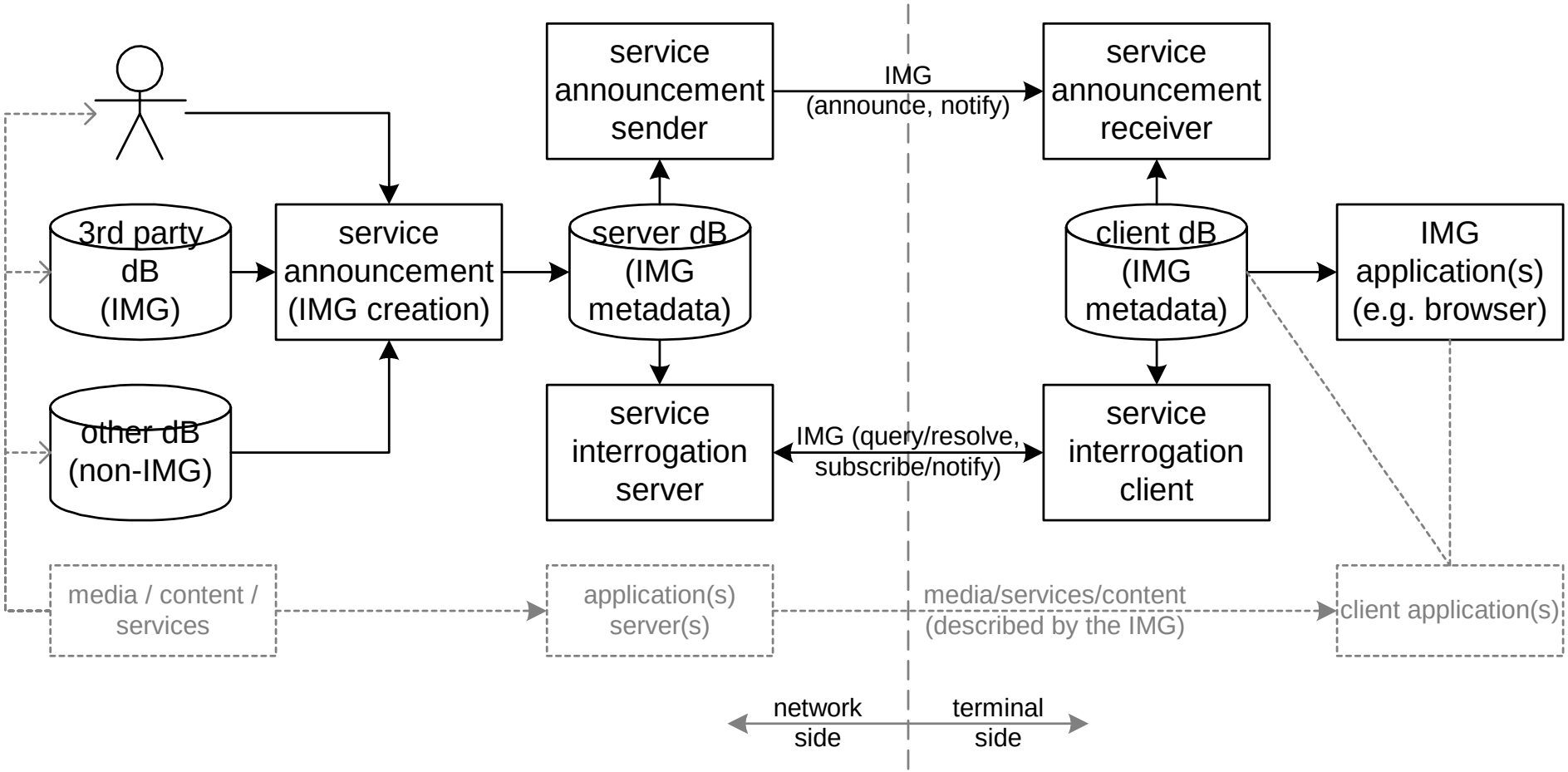
Simplified Client/Server Architecture for IMG



Where does the IMG fit? End-to-end



Where does the IMG fit? Building Blocks



3 Sets of Operations & 3 Data Types

QUERY/RESOLVE service metadata

(unicast request/response like HTTP)

ANNOUNCE service metadata

(multicast announcement like SAP)

SUBSCRIBE/NOTIFY of metadata change

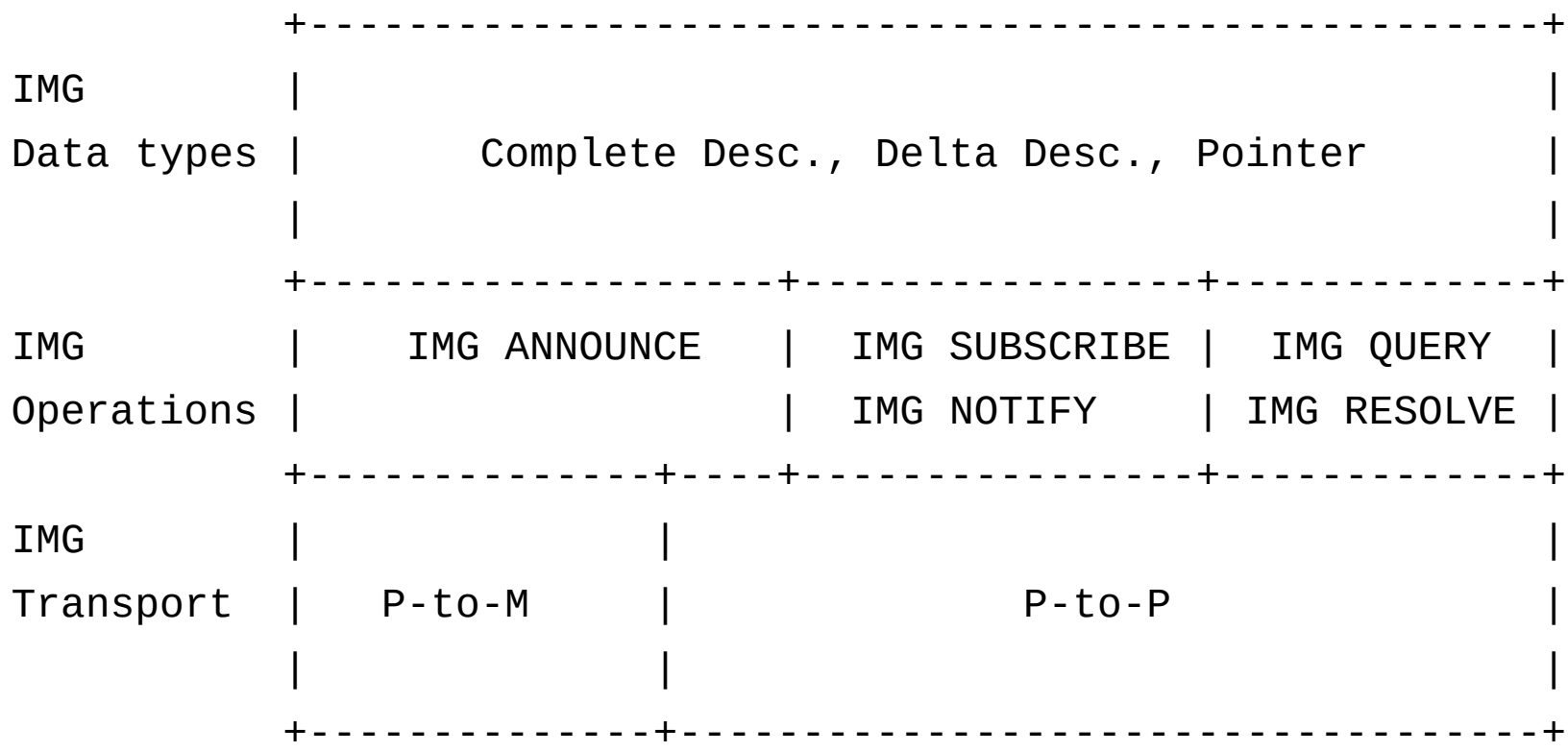
(unicast and multicast, SIP-like subscribe & notify)

Complete Descriptor - An identifiable well bounded block of metadata

Delta Descriptor – Partial information of a complete descriptor providing only the changes (diff/delta) since a previous version

Pointer – a pointer to a descriptor which has changed (for consistency checking without sending actual descriptor data)

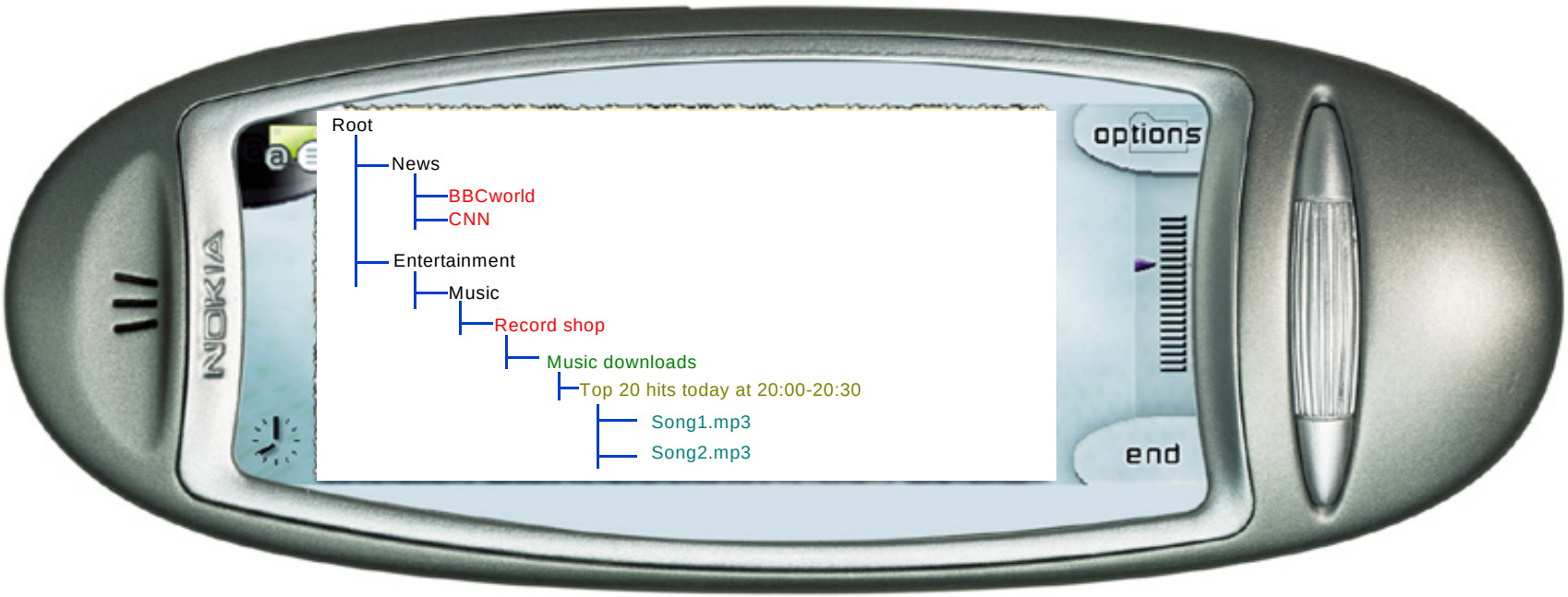
IMG Data Types - Operations – Transport Relation



IMG Operations and IMG Data types

How to use an IMG (1/4): The Media Guide

- Receiver has a cache of IMG metadata which describes available multicast media/content/service
- The user browses this metadata using a *Media Guide* application
- From the *Media Guide*, the use selects services/content/media which are available using another application (e.g. media player, file manager, etc.) (note, integrated media player + media guide applications are also allowed)



How to use an IMG (2/4): Metadata Delivery

- A Receiver would normally only store selected parts of IMG metadata in its local cache
  - since the total quality of network-wide metadata is not bounded
- A ”new” Receiver may have its initial cache:
  - pre-installed (e.g. by a network operator)
  - fetched by unicast either ”in the shop” or when a user first switches on
  - pushed to it by multicast over an initial period when it is first used
  - any combination of the above
- The Receiver may be able to add and refresh this cache by:
  - listening to multicast channels/sessions which contain updates
  - fetching the items by unicast (not a mandatory feature)
- A Receiver would know that it needs to update its cache because:
  - an element of metadata expires (if it has a limited lifetime)
  - the Receiver receives an explicit notification that some metadata has changed
  - the terminal checks (from multicast or unicast) the current metadata

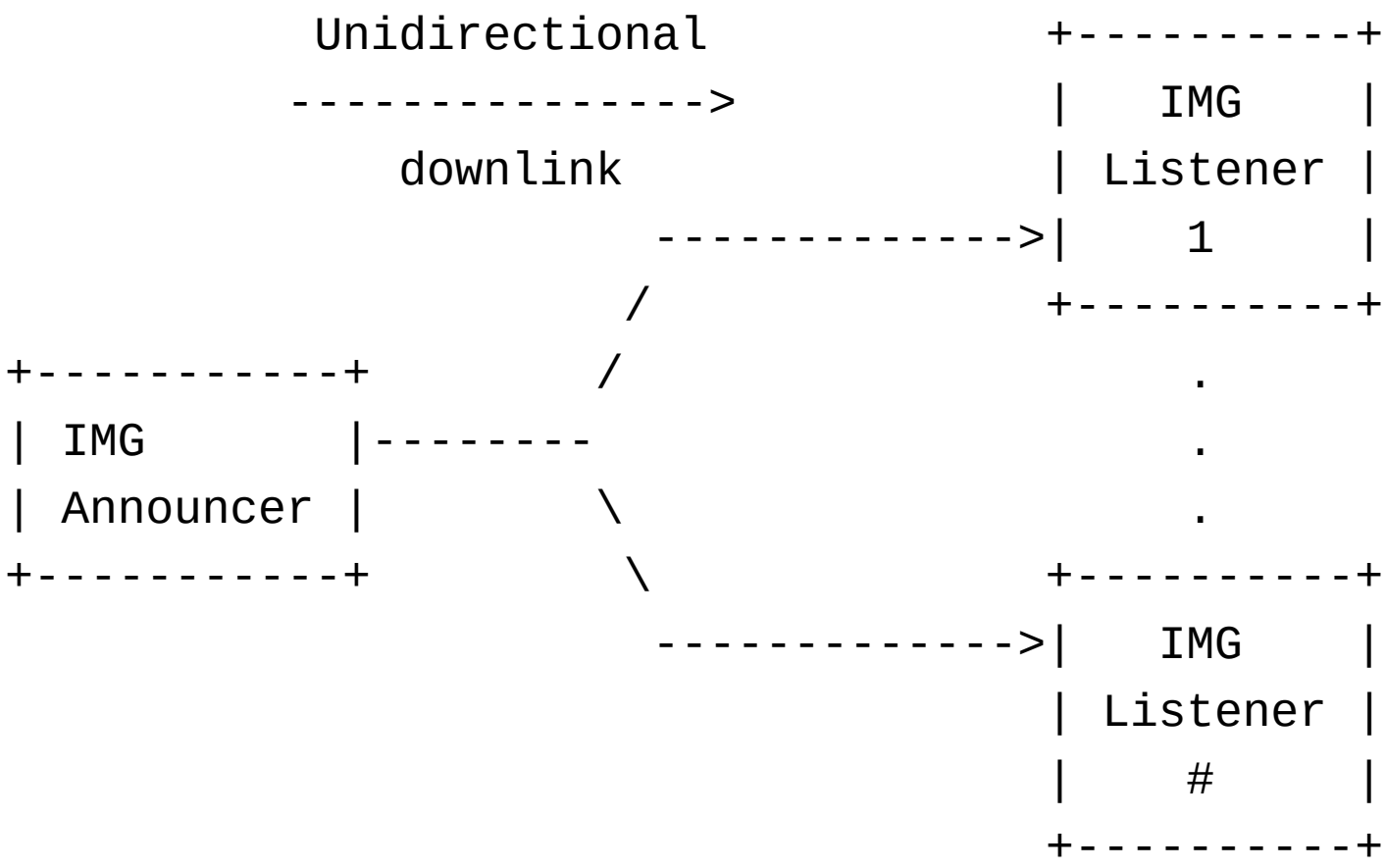
How to use an IMG (3/4): Providing Metadata

- Content Providers (and owners), and service aggregators will create metadata
  - preferably according to a well-known open standard
- IMG Servers provide IMG metadata and require storage
- An IMG Proxy (optional entity) may aggregate and filter one or more sources of valid IMG data (and may employ caching)
- In a certain domain (e.g. one operator's system) the total amount of metadata may be finite and known
- In the general Internet the total size of IMG metadata is unbounded
- Some providers may only need a subset of the features IMG provides (e.g. only use multicast, only describe streaming AV)
- (User created content including IMG metadata is not within existing IETF IMG focus. However, it is expected that the IMG specifications may also be useful outside the core use cases)

How to use an IMG (4/4): Bearer Specifics

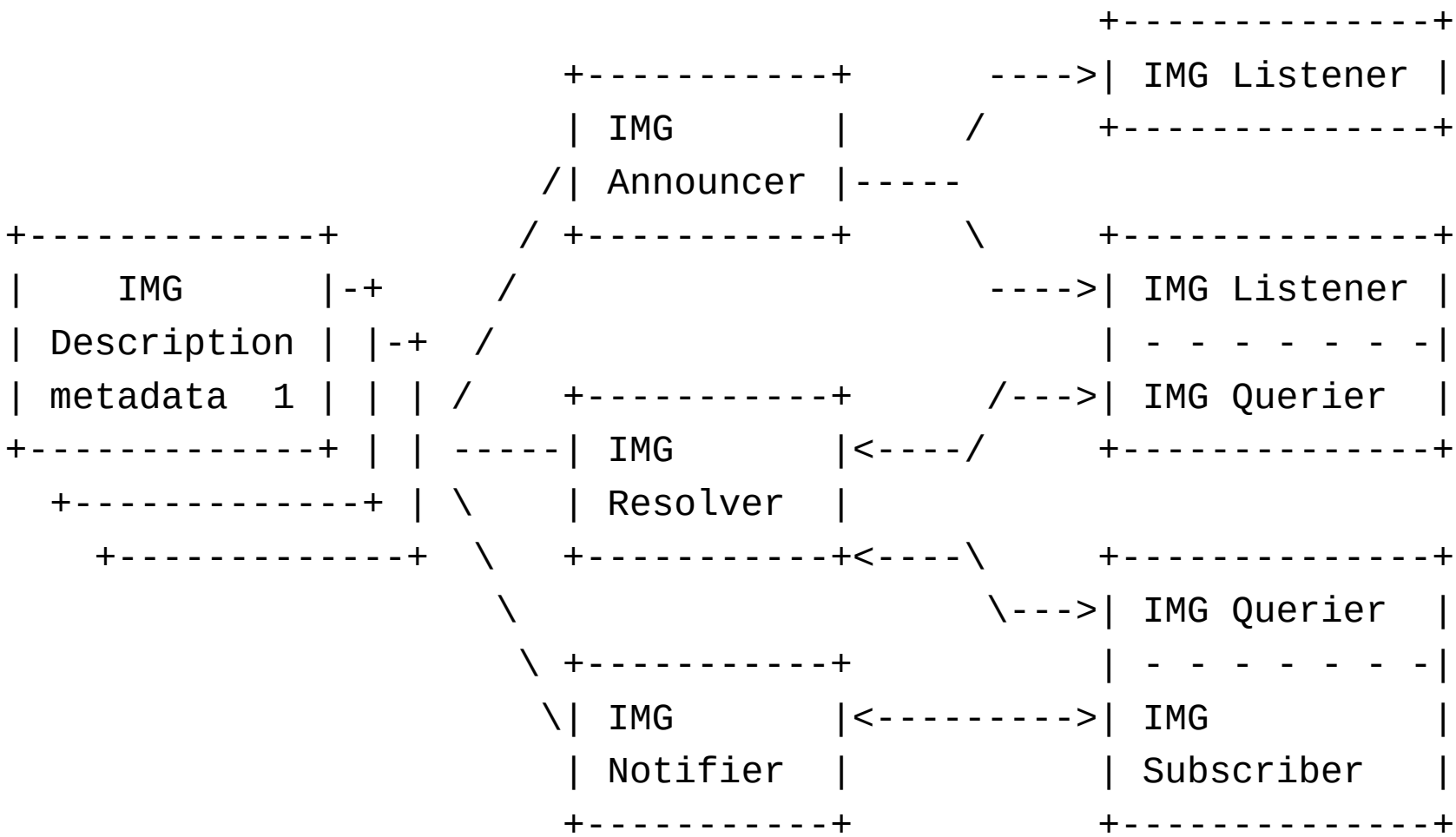
- IMG is bearer independent
  - IMG applies to MMM systems and the general Internet
  - IMG can be transported by unicast and multicast
  - IMG can describe unicast, multicast & any kind of services
  - IETF IMG specifications do not describe L1 and L2 (only L3/IP and above)
- For wireless MMM systems, a method to map the specific L1/L2 access channel with the L3+ sessions is essential
  - These mapping parameters are link specific (e.g. different for DVB-H and UMTS)
  - The mappings are between L3 (IP addressing) and L2.
- There are two methods to provide this mapping
  - Include the L2/L3 mapping as IMG metadata. This approach has not be followed.
  - The specific link bearer provides the mapping to L3. This approach has been adopted for all MMM systems.
    - (A bearer-specific notify standardised for that (e.g. radio) bearer. Examples include *notify messages*, *paging*, and *service information tables* provided ”below” the IP layer)
  - However, this is outside the scope of the IETF IMG specifications

IMG Service Announcement



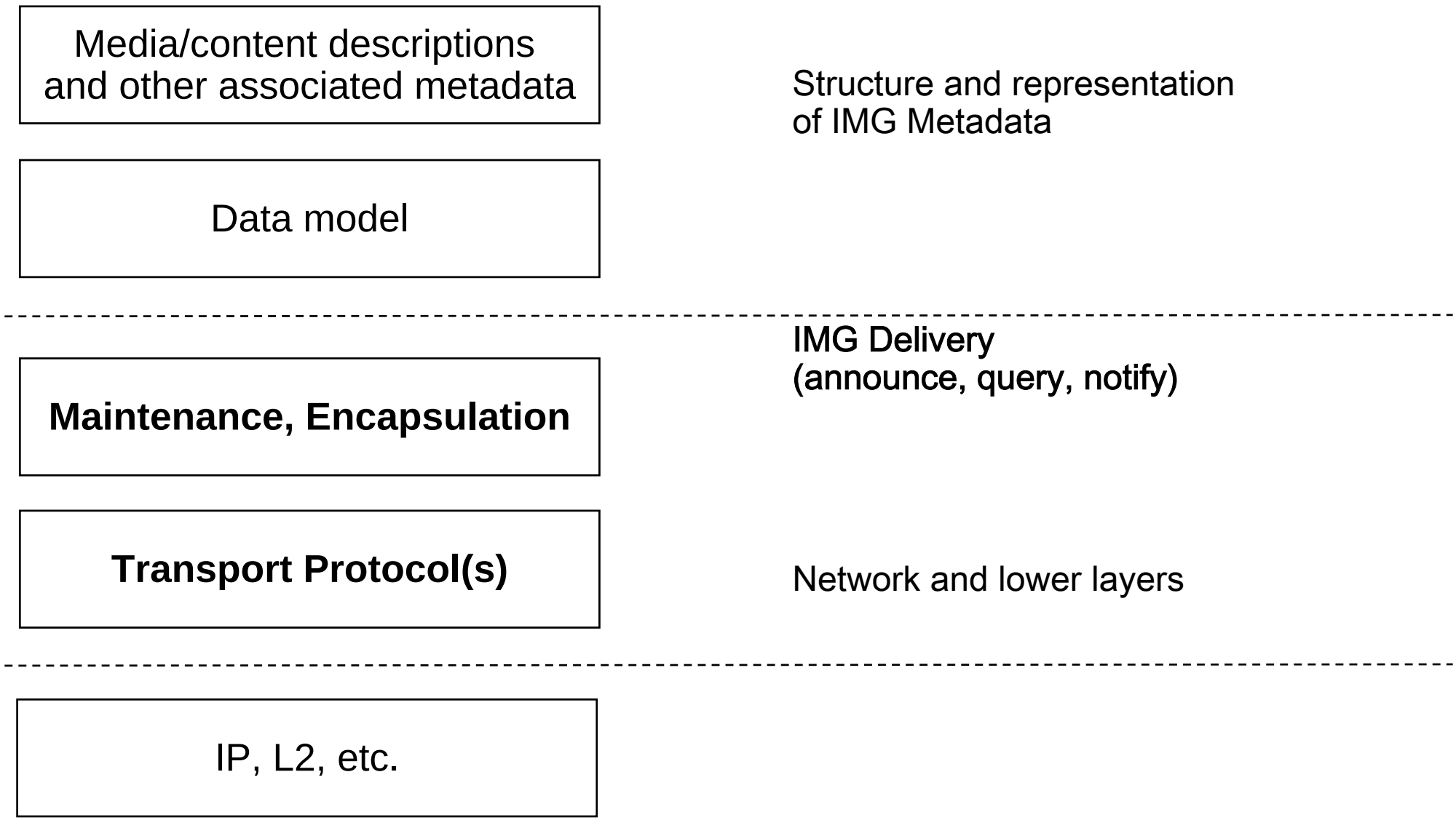
IMG Unidirectional Multicast Distribution Example

All IMG Entities

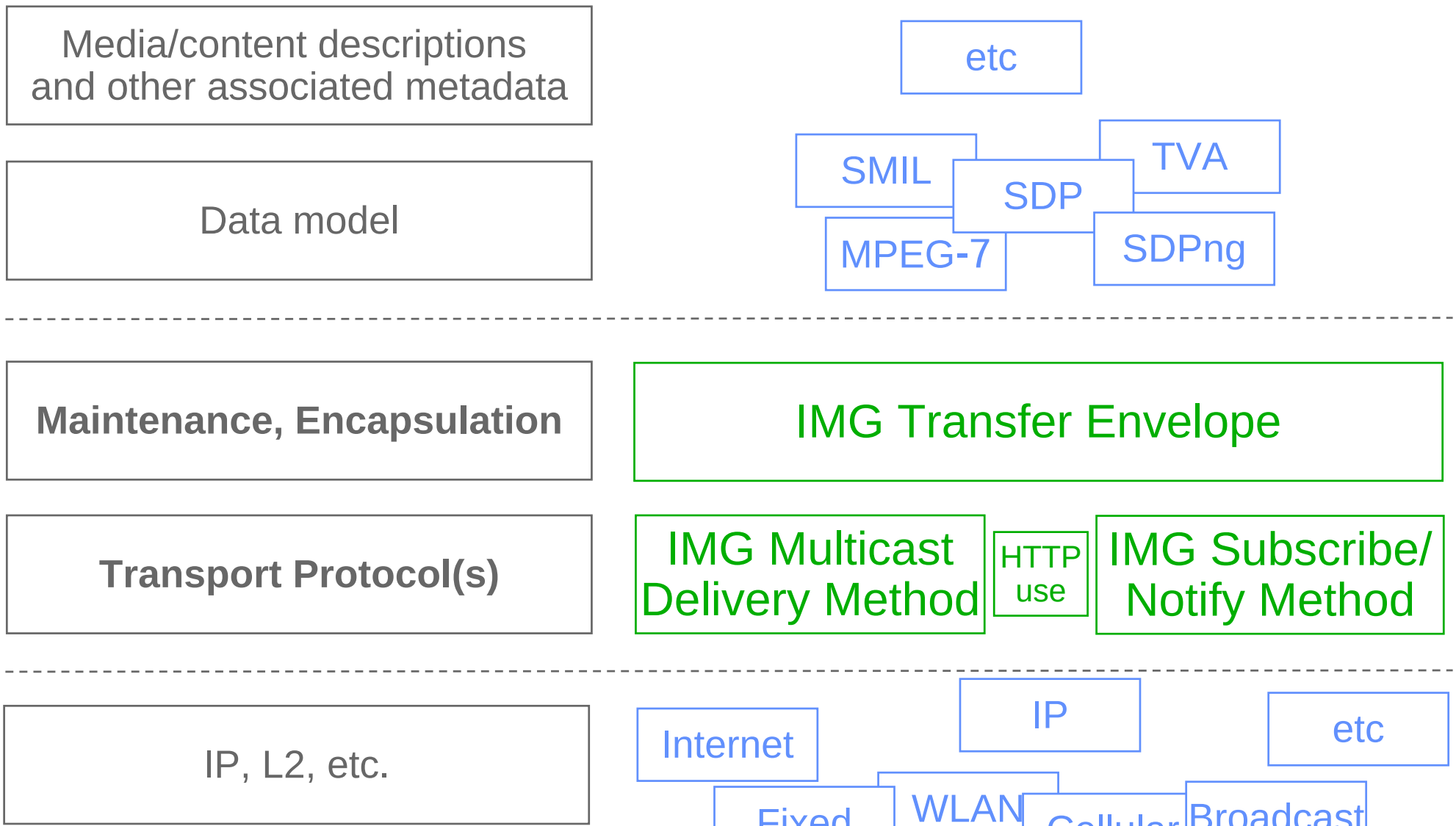


Combined System with Common Metadata

Layered Model of IMG Framework



Potential IMG Components



IMG Envelope

- Need to provide a common minimal set of information to manage transfers of IMG information
  - Independent of delivered IMG Metadata & of IMG Transport Protocol
  - Identify, Version & Validity/expiry time of “a block of” IMG metadata
- XML definition
  - As wrapper encapsulating an “Metadata Fragment”
  - As a pointer referencing a separate “Metadata Fragment (object)”
- New submission (draft-walsh-mmusic-img-envelope-01.txt)
  - Compatible with 3GPP metadata envelope!
  - New MIME content type for the envelope
  - Gentle pressure to make an MMUSIC charter item

Multicast Transport Protocol

- SAP (RFC 2974) does not match MMM Service Announcement needs
- Solution: specialize RMT-FLUTE
  - Provides all the basic functionality as file delivery
  - With reliability, fragmentation, channelization, etc.
  - IMG Metadata announcement can be abstracted as unidirectional multicast file delivery
  - A new and untested protocol from scratch is unnecessary
- New I-D submission needed
  - Focuses on the channelization of IMG transport
  - Bootstrap options need to be considered
  - 3GPP (and DVB) are currently ahead on this topic
  - Gentle pressure to make an MMUSIC charter item

IMG Unicast Subscribe & Notify Mechanism

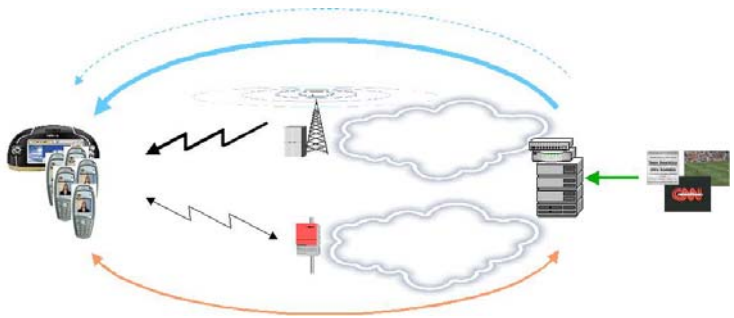
- Not essential for Mobile Mass Media
- HTTP does not meet the IMG requirements
  - Always-on sessions & polling do not scale (# of users & data quantity)
  - Need an update notification mechanism
- Working assumption is to base on SIP Event Notification
  - Already has SUBSCRIBE and NOTIFY functionality
  - Good candidate for update notification
  - Need to standardize “Event Package” for IMG
    - Take RFC 3427 into account (SIP change process)
  - Need “Envelope” to make IMG metadata delivery maintainable
    - Needs to support “delta description”
- Update needed to draft-nomura-mmusic-img-notify-00.txt
- Maybe to become an MMUSIC/SIPPING work item

IMG IETF Status Snapshot

- Passed WGLC (working group last call):
  - IMG Requirements <draft-ietf-mmusic-img-req-07.txt>
  - IMG Framework <draft-ietf-mmusic-img-framework-08.txt>
- These provide the IETF perspective on
  - Service, session, media description directories & distribution
  - IP-based program guides
- Future IETF charter items:
  - Service Announcement:
    - Delivery by FLUTE transport specialisations (muppet)
    - Metadata Transfer Envelope (envelope)
    - Explicit Target: Backwards compatible & IOP with 3GPP
  - How to use SIP for subscribe/notify & HTTP for based query/response

IETF Documents of Interest

Enabling Technologies



IETF Documents of Interest (1/2)

- Streaming
  - RFC 3550 (RTP)
  - draft-ietf-avt-rtp-h264-11.txt (MPEG4 AVC payload, passed WGLC)
  - draft-ietf-avt-rtp-amrwbplus-01.txt (AMR-WB+ payload)
  - RFC 3016 (MPEG-4 AV Streams payload – for enhanced AAC+)
  - draft-ietf-avt-rtp-3gpp-timed-text-07.txt (timed-text/subtitling)
  - <draft-luby-avt-rtp-generic-fec-01.txt> (RMT FEC for RTP)
  - <RFC 3452> (RMT FEC Building block, update for RTP capability planned)
- Download
  - RFC 3926 (FLUTE + referenced RFCs)
  - RFC 3695 (compact no code FEC)
  - <draft-peltotalo-rmt-bb-fec-supp-xor-pcm-rs-00.txt> (FEC)
  - <draft-luby-rmt-bb-fec-supp-simple-00.txt> (FEC)
  - <draft-luby-rmt-bb-fec-raptor-object-00.txt>
  - <draft-mehta-rmt-flute-iop-02.txt> (interoperability guidelines)
- Post-delivery procedures
  - <RFC 2616> (HTTP - for file repair & reception reporting)

<indicates leadership also outside IETF>

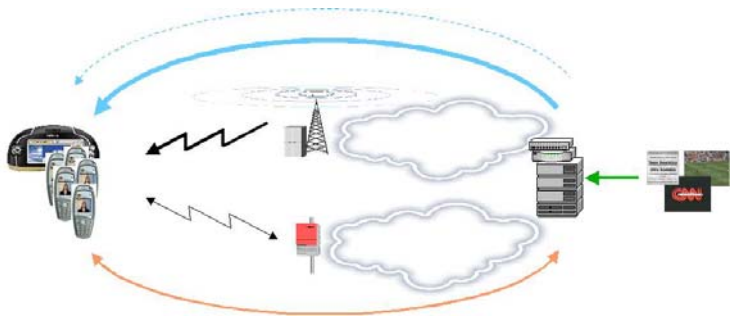
<indicates no immediate impact outside IETF>

IETF Documents of Interest (2/2)

- IMG
  - draft-ietf-mmusic-img-req-07.txt (requirements, passed WGLC)
  - draft-ietf-mmusic-img-framework-08.txt (framework , passed WGLC)
  - <draft-walsh-mmusic-img-envelope-01.txt> (envelope)
  - <draft-luoma-mmusic-img-muppet-05.txt> (flute-based announcement, expired)
  - <draft-luoma-mmusic-img-metadata-04.txt> (baseline metadata model, expired)
  - <draft-nomura-mmusic-img-notify-00.txt> (sip subscribe/notify mechanism)
- Metadata
  - draft-ietf-mmusic-sdp-srcfilter-06.txt (source address in SDP, passed WGLC)
  - <draft-mehta-rmt-flute-sdp-02.txt> (extensions for flute session description)
- Security
  - RFC 3711 (SRTP)
  - draft-ietf-mmusic-kmgmt-ext-11.txt (SRTP key data in SDP + MIKEY key mgmt)
  - <draft-ietf-mmusic-sdescriptions-07.txt> (key data in SDP for unicast streams)
  - <draft-ietf-msec-srtp-tesla-01.txt> (telsa authentication when using SRTP)
  - RFC 2406 (IPsec-ESP)
  - RFC 3830 (Msec-MIKEY)

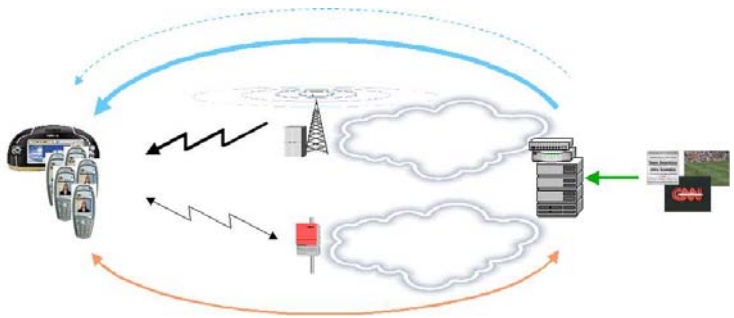
<indicates leadership also outside IETF>

<indicates no immediate impact outside IETF>



MBMS: Multimedia Broadcast Multicast Service

3G MMM enhanced system

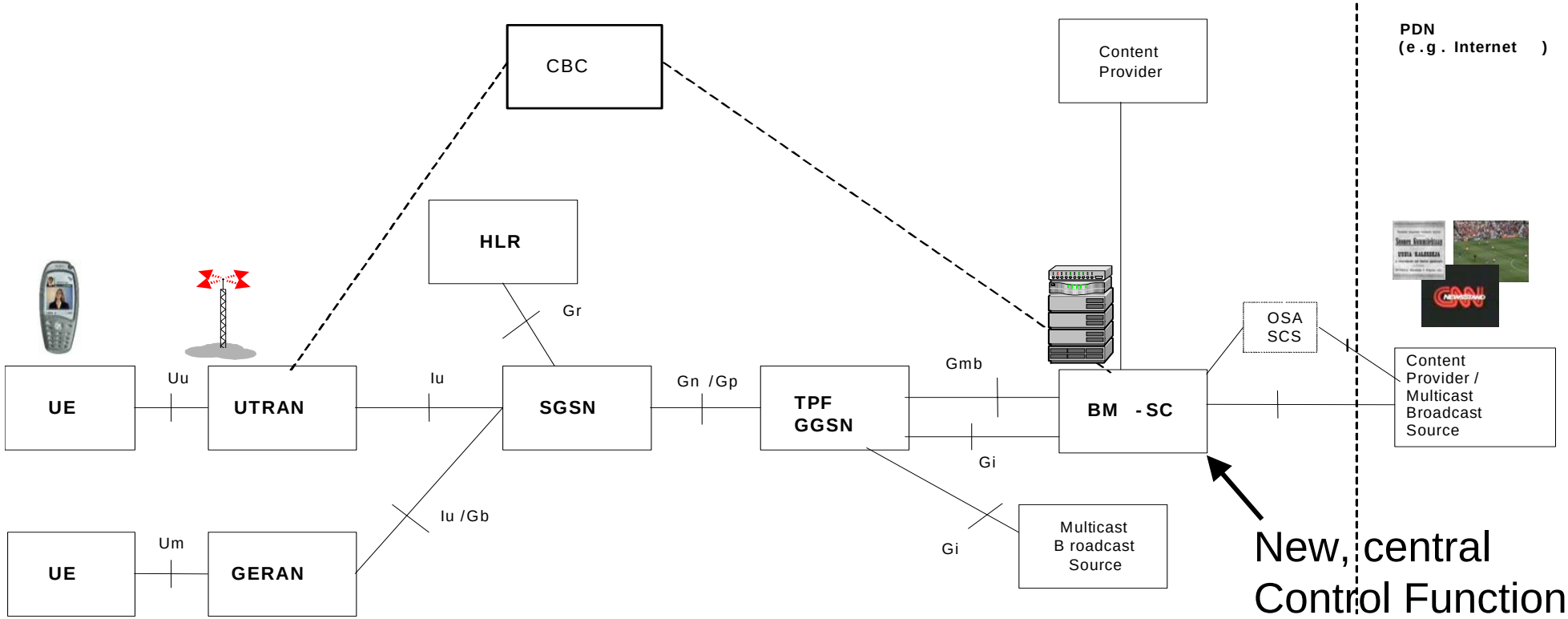


Where does MBMS Come From?

- 3GPP and constituent members identified a need to standardise:
  - Multimedia Broadcast Multicast System
  - For efficient one-to-many content-over-IP distribution
  - In cellular networks
- Working Groups (WGs)
  - SA – System Aspects
    - SA1: specifies requirements
    - SA2: system architecture
    - SA3: security aspects
    - **SA4: codecs and protocols**
  - CN – Core Networks: routing, switching and distribution (areas)
  - RAN – UMTS Radio Access Network: radio bearer
  - GERAN – GPRS/EDGE Radio Access Network: radio bearer
- SA4 is the WG with the mandate to work on:
  - download, streaming and service announcement for MBMS
  - Hence, SA4 is the focus of this presentation

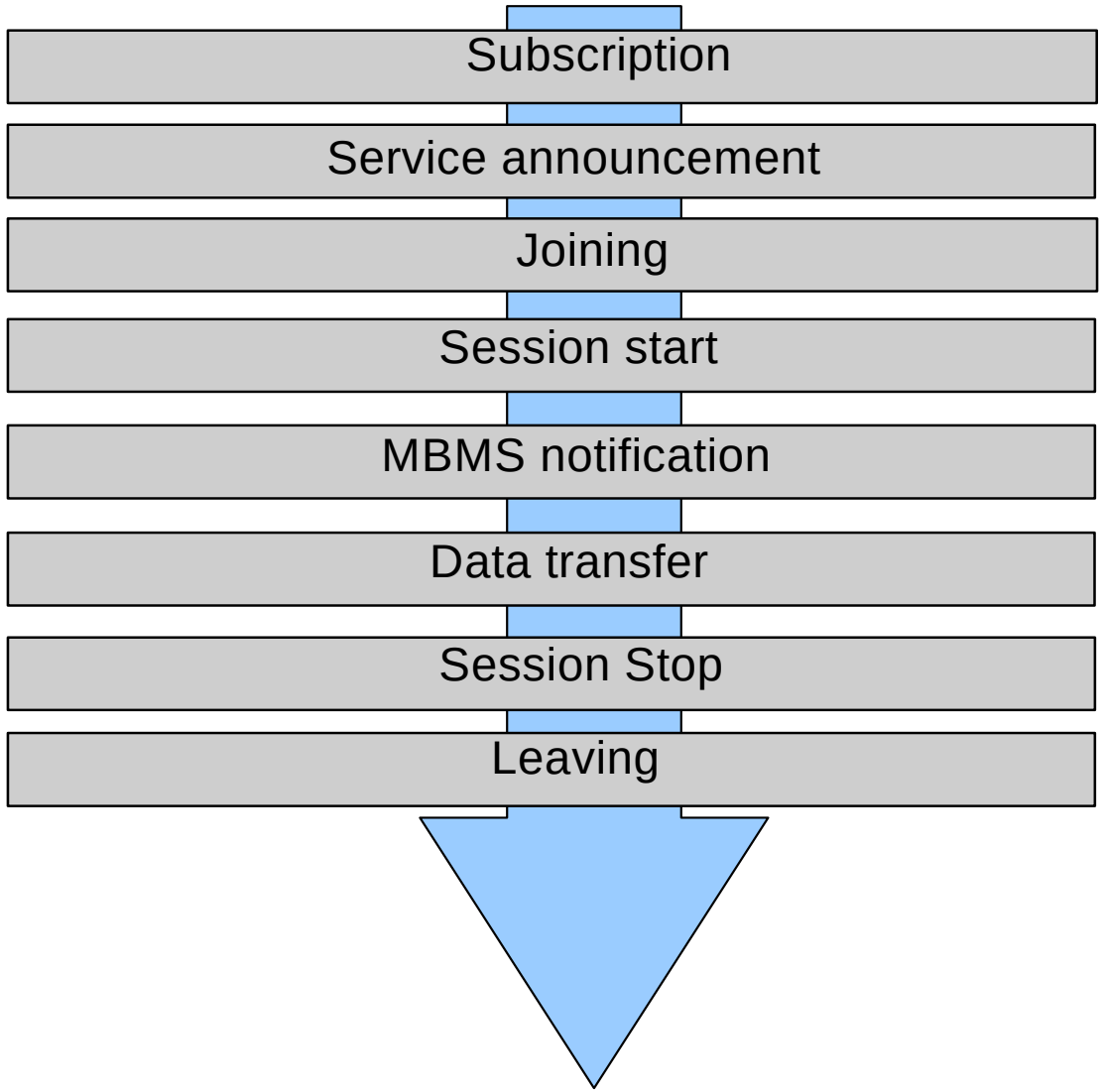
(There's lots of information at http://www.3gpp.org)

MBMS architecture: Reference model

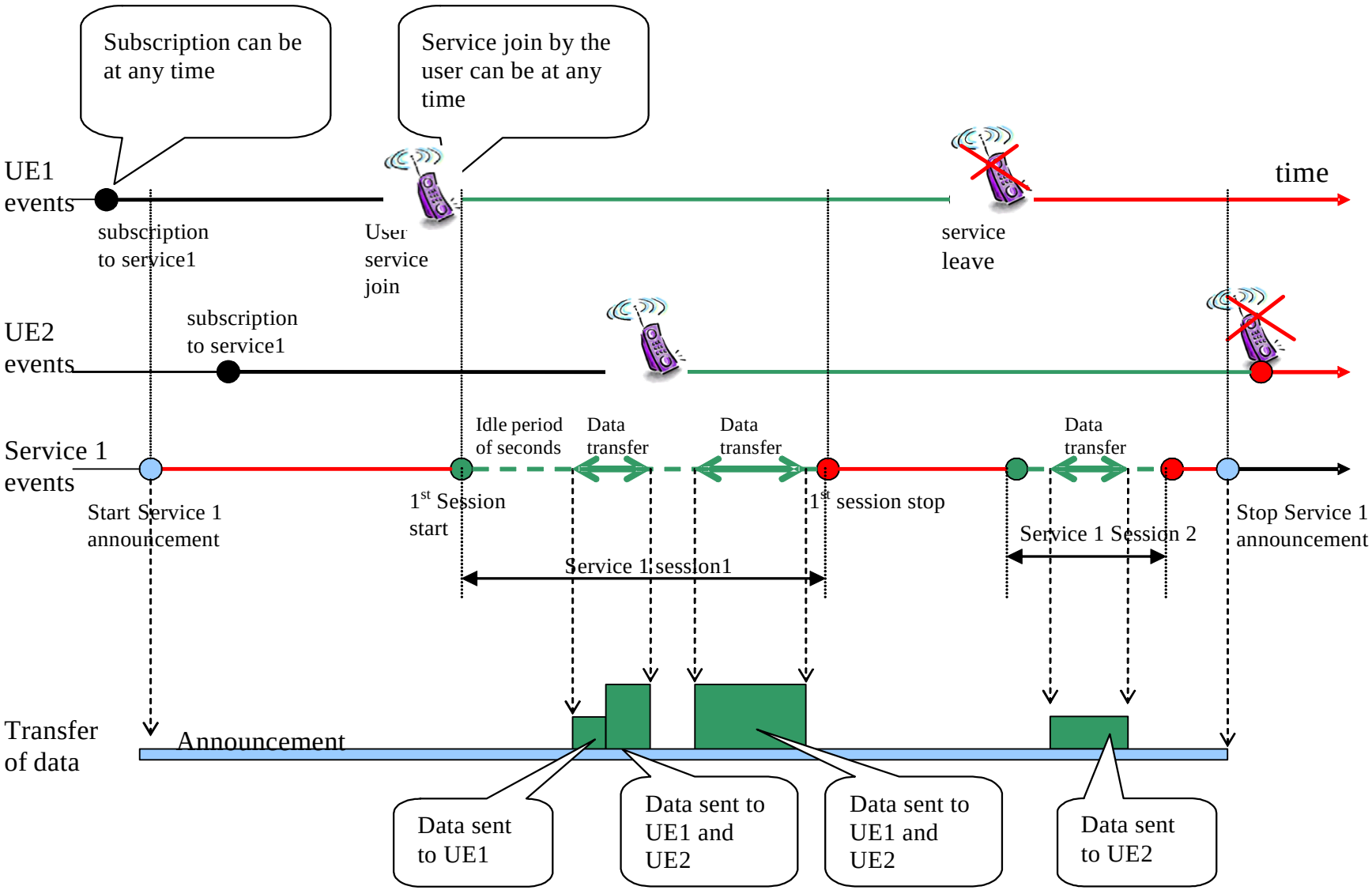


- Existing packet switched (PS) domain entities (GGSN, SGSN, UTRAN and UE – User Equipment) are enhanced to provide the MBMS Bearer Service
- This service provides delivery of IP Multicast datagrams from Gi reference point to UEs with a specified QoS
- Broadcast Multicast Service Center (BM-SC) provides a set of functions for MBMS User Services

MBMB architecture: Multicast procedures



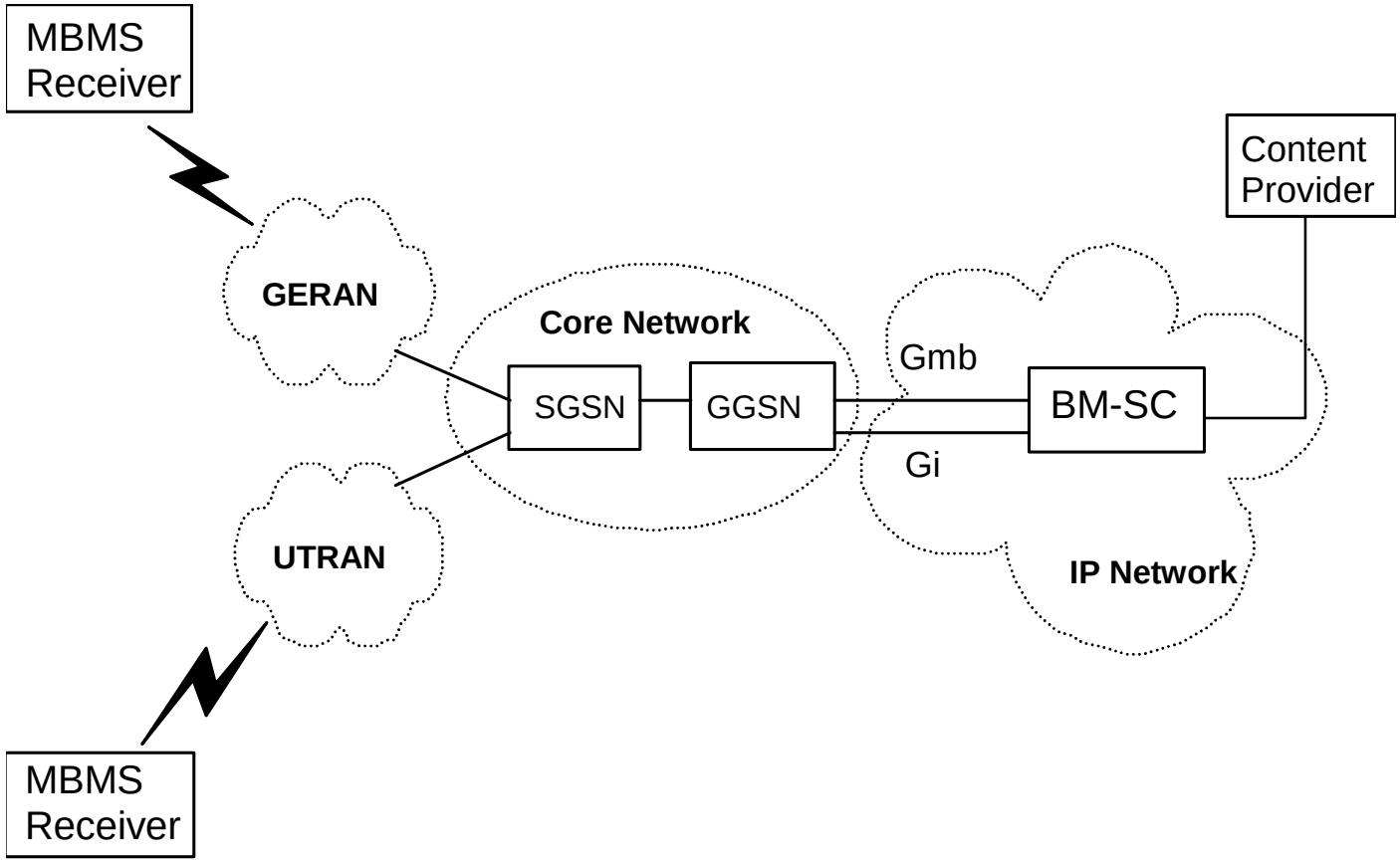
MBMS Architecture: Multicast timeline example



MBMS user services: Application level protocols and codecs

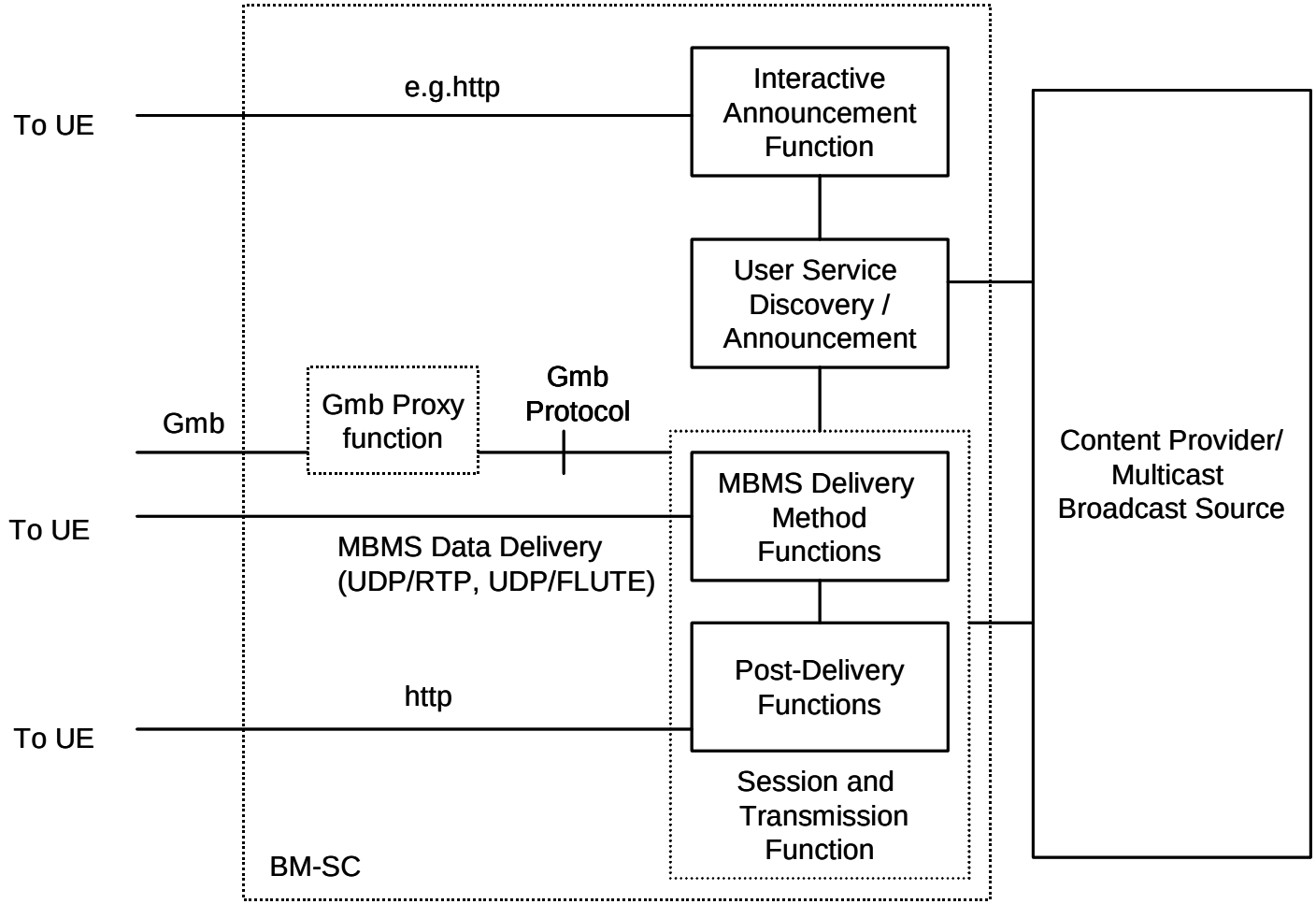
- The input for this part comes from:
  - 3GPP TS 26.346
  - 3GPP TR 26.946
  - 3GPP SA4 meeting contributions and discussions
- The information is based on a current snap shot and expectations for standardisation in 3GPP release 6
  - MBMS Release 6 will be final in December 2004 (only bug-fixes after)

MBMS Network Architecture



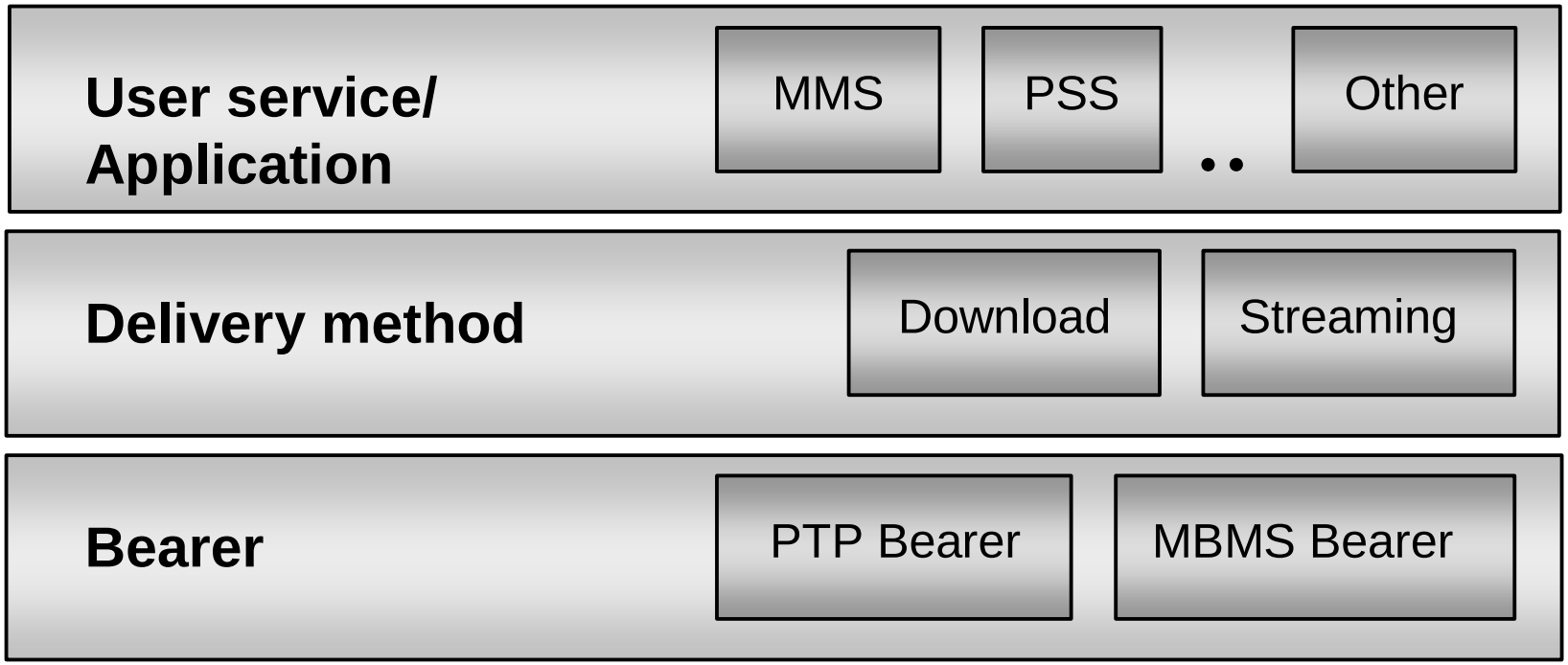
- Terminals have both MBMS ptm and normal PS ptp connectivity
  - (point-to-point/multipoint, packet switched)
- Minimal use of ptp interactive messaging is essential for scalability (and thus MBMS success)

MBMS user services: BM-SC

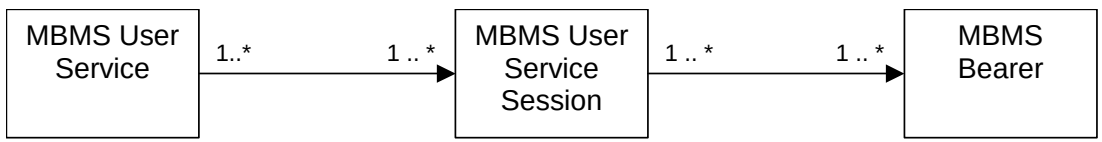


- The “Broadcast Multicast Service Center” (BM-SC) is the network-end focus of “over IP” functionality comparable to IP Datacast
- The MBMS Receiver (or UE) is the client/terminal

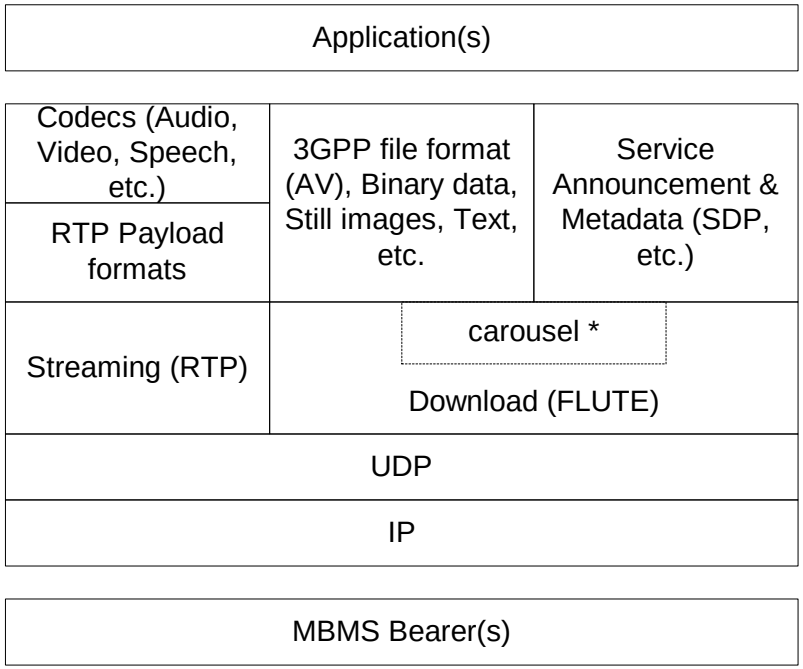
Layered Approach to MBMS Technologies



- This layered approach closely relates to protocol layers
- SA4 is concerned with Delivery Methods and partly User service and applications



MBMS PtM Protocol Stack



Goals:

- Fulfil SA1 requirements
- Fit SA2 framework
- Maximise commonality with IETF
- Maximise commonality with PSS
  - (Packet Switched Streaming)
- Ensure feasibility for mobile devices

Download delivery:	FLUTE (all discrete file types)
Streaming delivery:	RTP (audio, video, {continuous subtitle text})
Service Announcement:	Download method (FLUTE)
	{interactive allowed not specified/standardised}
Service Metadata:	Session Description in SDP,
	{“User Service Description” in XML}
{Carousel delivery:	Download method (FLUTE), not expected in release 6}

3GPP Audio: PSS, MMS, MBMS

- Release-5 (PSS, MMS):
  - No mandatory audio codec
  - MPEG-4 AAC LC: Strongly recommended to be supported
  - MPEG-4 AAC LTP: weaker ”may be supported”
  - Mono and stereo, up to 48 kHz, not limitations to the bit rate
  - AMR-WB mandatory for wideband speech applications
- Release-6 (PSS, MMS):
  - No mandatory audio codec but Extendend AMR-WB (”AMR-WB+”) and Enhanced AAC+ (”MPEG-4 HE AAC v2”) are both strongly recommended to be supported for PSS and MMS specifications includes ”recommended usage” according to the bit rates and content types
  - Complexities of both AMR-WB+ and e-AAC+ are below 3GPP design constraints
  - AMR-WB+ specified in TS 26.290, includes bit rates up to 48 kbps
  - MPEG-4 AAC LC and MPEG-4 AAC LTP: weaker ”may be supported” due to backward compatibility to Release-5
  - Test report on 3GPP Low-Rate Audio Codec Exercises: 3GPP S4-040173
- Release-6 MBMS:
  - Discussion going on, both AMR-WB+ and e-AAC+ have been proposed

MBMS user services: Delivery Methods

- Streaming
  - RTP is IETF specified
  - Limited codec and RTP payload selections
    - H.264, tbd: ext AAC+ / AMR-WB+
  - FEC code usage specification anticipated (later to IETF)
- Download
  - FLUTE is IETF specified
  - Some FLUTE fields made mandatory (for simpler implementation & iop)
  - File types probably will not be limited
    - (but IANA content type registration is advantageous)
  - FEC code usage may be specified in 3GPP (later to IETF)
- (R-S, LPDC and raptor codes are FEC candidates)

MBMS user services: Service Announcement (1/2)

- FLUTE is used for transport
- Metadata Envelope is used for metadata maintenance
  - _Minimalist_ XML schema
  - Provides versioning and time validity of metadata fragment
  - References metadata fragment
  - Will enabled embedding of metadata fragment
- Multiple metadata fragment syntaxes allowed
  - IANA registration to follow {IETF or 3GPP tree}
  - application/sdp & application/xml use expected in MBMS

Continued...

MBMS user services: Service Announcement (2/2)

- A metadata fragment is a well defined “block” of metadata
  - Each is “uniquely” identified
  - {theoretically any number of attributes and any size}
  - Specific purpose fragments of predictable, and not large, size
  - Syntax specification per fragment is simplest approach
  - (3GPP only defines only the minimum required for interoperable MBMS service & bearer usage)
  - Definitions expected for release 6
    - “Session Description” (SDP for max. FLUTE/RTP commonality & reuse)
    - “User Service Description” (XML) – service identification and linkage to sessions / delivery methods
    - “Associated Delivery Procedure Description” (XML) – file repair & reception acknowledgement parameters
    - {tbd: “Security Description”}
- {DVB then OMA are expected to increase the metadata set}

Metadata Fragment (1/2)

User Service Description

- Unique Service Identifier
- Service type: streaming, messaging, etc.
  - (to launch the right application in the terminal)
- service-language(s)
- session identification
- Associated delivery procedure on/off, related parameters: for file repair and delivery reporting
- security on/off and related parameters

Metadata Fragment (1/2)

Session Description

- QoS, data rates, UE MBMS bearer capability requirements
- user service session start/stop time
- Destination Port number, Source and Destination IP addresses, protocol, (delivery method)
- service-language (per media)
- media types and codecs
- FEC on/off, related parameters
- mode of bearer(s): broadcast/multicast

Session Description Example

- Only new (to IETF) parameters are for FLUTE

```
v=0
o=user123 2890844526 2890842807 IN IP6 2201:056D::112E:144A:1E24
s=File delivery session example
i=More information
t=2873397496 2873404696
a=source-filter: incl IN IP6 * 2001:210:1:2:240:96FF:FE25:8EC9
a=flute-tsi:3
m=application 12345 FLUTE/UDP 0
c=IN IP6 FF1E:03AD::7F2E:172A:1E24/1
```

- Start time, end time
- Source address, transport session identifier
- Destination port, protocol ID, fmt-list (e.g. media subtypes)
- Destination address (1 channel)

Associated Delivery Procedures

For release 6:

- Post delivery file repair
  - Point-to-point (interactive) repair
  - {point-to-multipoint repair maybe in r6}
- Post delivery reception reporting
  - Statistical reports (for QoS reporting)
  - Reception acknowledgement
    - {not assumed to be secure enough for billing}
  - For both streaming and download

MBMS Security in Brief

- Specified in TS 33.246
- MBMS security functions
  - Authenticating and authorizing the user
  - Key management and distribution
  - Protection of the transmitted traffic
- Uses
  - Generic Bootstrapping Architecture (for KEK)
  - MIKEY (for key and content encrypting keys)
  - SRTP (for stream traffic protection)
- Not finalised
  - File content protection (DRM is a good candidate. Also S/MIME & others)
  - File traffic protection (IPsec is feasible)

MBMS Security: UE and BM-SC Roles

- Role of BM-SC in MBMS Security
  - Responsible for generating and distributing the necessary keys to the UEs
  - Applies the appropriate protection to transmitted data
  - Provides the MBMS bearer authorisation for UEs attempting to establish multicast bearer
- Role of the UE in MBMS Security
  - Responsible for receiving or fetching the needed keys from B-SC
  - Decrypts the received MBMS data

MBMS Security: MBMS keys

- MBMS Request Key (MRK):
  - to authenticate the UE to the BM-SC when e.g. performing key requests
  - generated simultaneously with MUK using GBA
  - stored in ME
- MBMS Service Key (MSK)
  - shared by a BM-SC and UEs that can access a particular service
  - used to protect the delivery of MTKs
  - sent to UE in MIKEY message
  - stored in ME or UICC
- MBMS Traffic Key (MTK):
  - used to decrypt the received MBMS data on the ME
  - sent to UE in MIKEY message
  - stored in ME
- MBMS User Key (MUK):
  - the MBMS user individual key used to protect point-to-point transfer of MSKs to the UE
  - generated using GBA
  - stored in ME or UICC

MBMS Security: MBMS key management and distribution

- GBA (Generic Bootstrapping Architecture, see TS 33.220) is used to generate keys (MUK and MRK) shared by UE and BM-SC
  1. Bootstrapping Server Function (BSF) and UE run AKA to generate shared keys
  2. UE contacts BM-SC requesting service
  3. BM-SC asks BSF for key generated from key shared by BSF and UE and derives MUK and MRK
  4. UE also generates MUK and MRK and MBMS service is securely delivered

- MIKEY is used to carry MSK and MTK keys to the UE
  - Three modes of transmission for MSK:
    - Push: Normal mode
    - Pull: When UE has protected data, but not the correct MSK
    - Push initiated Pull: Used when the BM-SC wants to refresh MUK/MRK or explicitly authenticate the UE receiving the key
  - MTK is delivered to the UE in Push mode

MBMS Security: Authentication and authorization

The UE is authenticated and authorized when

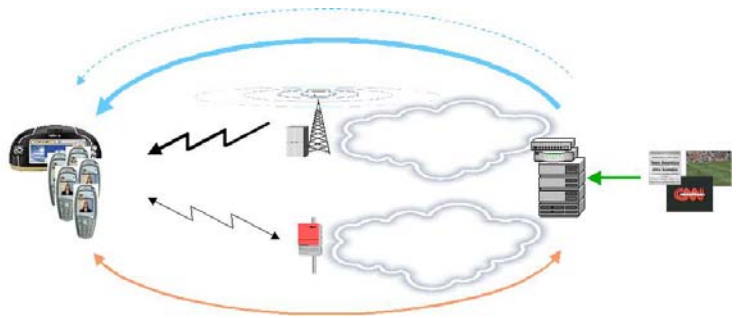
- Performing User Service joining on application level
  - HTTP digest authentication is used (MRK is used as password)
- Establishing the MBMS bearer(s) to receive an MBMS User Service
  - Authentication relies on the authenticated point-to-point connection with the network security described in TS 33.102 or TS 43.020
  - Authorisation for the MBMS bearer establishment happens by the network making an authorisation request to the BM-SC to ensure that the UE is allowed to establish the MBMS bearer(s) corresponding to an MBMS User Service (see TS 23.246)
- Requesting MSK(s)
  - The UE is authenticated with HTTP digest
- Performing post delivery procedures
  - The UE is authenticated with HTTP digest

MBMS Security: Traffic protection

- Applied end-to-end between BM-S and the UEs
- Can be either confidentiality protection or confidentiality and integrity protection
- Based on symmetric key shared between the BM-SC and the UEs that are currently accessing the service
- Actual method of protection may vary on the type of data being transferred, e.g. streaming or download
- SRTP is used for protection of the streaming data
- The method for protection of the download data is still open, current working assumption in 3GPP SA3 is S/MIME but this will be revised

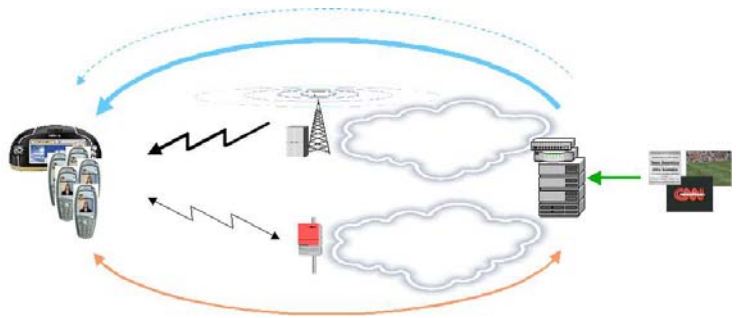
MBMS Specifications in 3GPP

- Technical specifications:
  - TS 22.146 "Multicast Broadcast Multimedia Service (MBMS)-Stage 1
  - TS 22.246 “MBMS User Services”
  - TS 23.246 " Multimedia Broadcast/Multicast Service (MBMS);Architecture and Functional Description (Release 6)"
  - TS 25.346 "Introduction of Multimedia Broadcast Multicast Service (MBMS) in RAN”
  - TS 26.346 “MBMS teleservice codecs and protocols”
  - TS 33.246 " Security of Multimedia Broadcast/Multicast Service "
- Technical Reports:
  - TR 29.846, "Multimedia Broadcast Multicast Service; CN1 Procedure Description (Rel-6)”
  - TR 25.803, ” S-CCPCH performance for MBMS;
  - (Release 6)”
  - TR 25.992 "Multimedia Broadcast Multicast Service (MBMS); UTRAN/GERAN Requirements"
  - TR 23.846 "Multimedia Broadcast/Multicast Service; Architecture and Functional Description”



IP Datacast over DVB-H

Mobile IP broadcast system



Expected IPDC Additions to MBMS rel. 6

Service Announcement/Discovery:

- More attractor metadata (to make the service appealing to users)
- Purchase related metadata
- Reuse of a subset of TVAnytime concepts and XML
- {Specification of interactive retrieval of metadata}
- Also a DVB relationship with OMA (SA4-BCAST liaison has started)

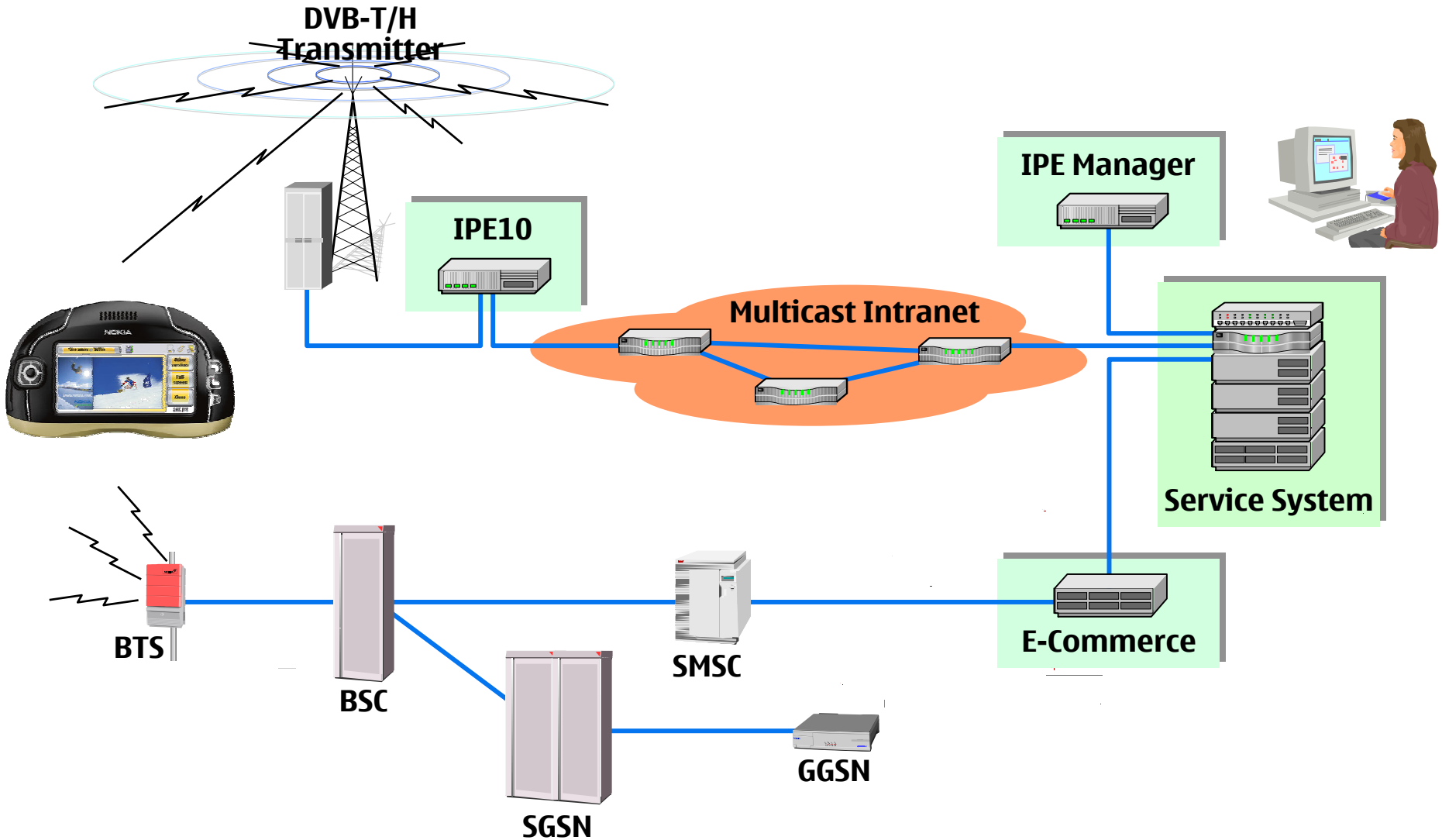
Delivery:

- File Carousel: enhancements for efficient use of FLUTE for carousels
- Guidance on achieving reliability: balance between TS R-S, MPE-FEC, Transport (FLUTE/RTP) FEC, repetitions, carousels, file repair
- {Are multiple FLUTE channels per FLUTE session useful to IPDC?}

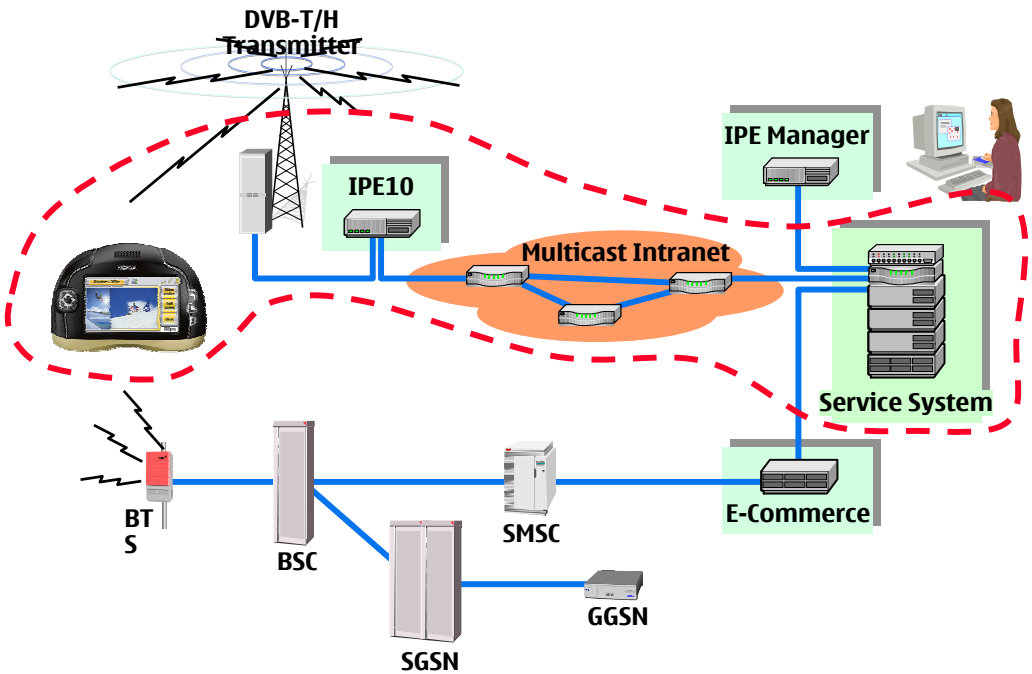
Handover/roaming:

- (Release 6 assumption is service discontinuity under handover is acceptable)

IPDC Solution

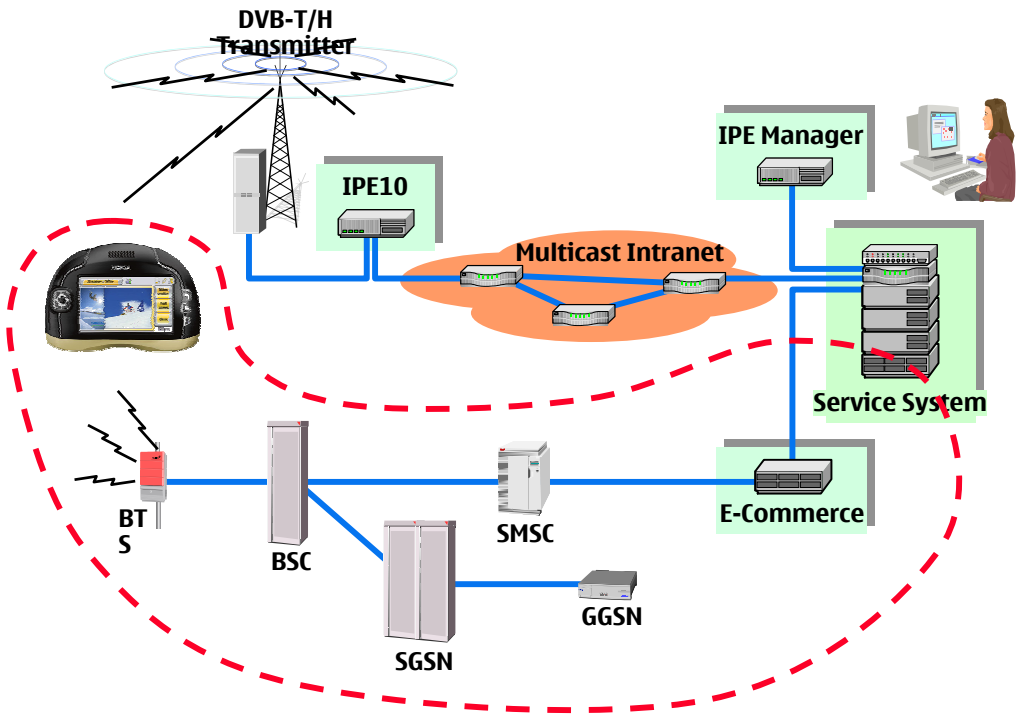


Service Provisioning over Broadcast Channel



- Streaming
  - RTP – same as MBMS
- Download
  - FLUTE – same as MBMS
  - Define file carousels and grouping
  - (Maybe allow multiple FLUTE channels)
- Delivery of Electronic Service Guide
  - Use 3GPP/MBMS solution
  - With IPDC file carousels
- Data model for Electronic Service Guide
  - ETSI TS "IPDC in DVB-H"
  - Future OMA work expected
  - (TVAnytime etc. adoption unknown)

Interaction Channel



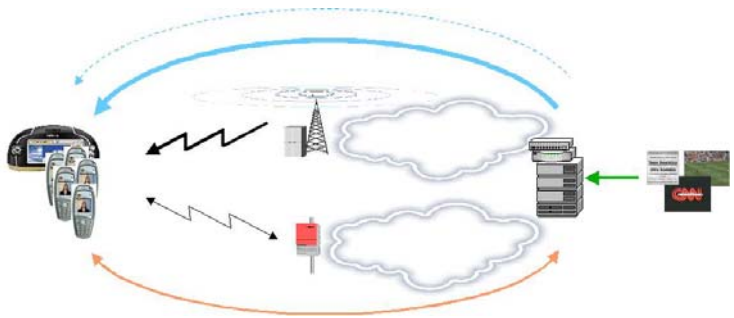
- Commonality with MBMS “to be attempted”
- Purchase request
- Rights Object (DRM) (also for flows/traffic)
- Interface between E-Commerce and Service System (work in progress)
- Cellular interaction channel planned

DVB-IPDC Audio & Video Codecs

- Proposed to define three capability classes IPDC-IRD A, IPDC-IRD B and IPDC-IRD C all using MPEG-4 AVC as the video and AMR-WB+ as the audio format according to the table below

	IPDC-IRD description	**Video:** MPEG-4 AVC Baseline (with constraint_set1_flag = 1)			**Audio:** AMR-WB+
Capability classes	Targeted for:	Video Codec Level	Max. video bitrate [kbps]	Max. frame rate at max. resolution	Max. audio bitrate [kbps]
IPDC-IRD **A**	Lowest end miniature receivers	Level 1b	128	15 fps QCIF	48
IPDC-IRD **B**	Pocketable devices and category	Level 1.2	384	15 fps CIF	48
IPDC-IRD **C**	Handheld devices with larger resolution screens	Level 1.3	768	30 fps CIF	48

Differences Between MMM Systems



MBMS and other cellular broadcast alternatives

- **MBMS**
  - Low-to-medium bit rate multimedia content
  - Cellular network solution
    - Possibility to limit transmissions only to areas populated by recipients
    - For wide-area delivery, less efficient than DVB-H
  - Uplink easily accessible, with scalability considerations
- **Cell/SMS broadcasting**
  - Low bit rate messaging
  - Cellular network solution
  - Uplink easily accessible
- **Cellular point-to-point delivery**
  - Low-to-high bit rate multimedia content
  - Cellular network solution
    - Efficient only when delivering content to a few individual recipients
  - Uplink easily accessible

Complementary IPDC and MBMS

IPDC over DVB-H and 3GPP/MBMS

- **Definition:**
  Enables programmed delivery of a broad selection of continuous mass media services over wide-area.
- **Service example:**
  20 TV channels for mobile device available country-wide [each channel 384kbit/s]
- **Implementation:**
  Networks: Dedicated DVB-H network required. Can be based on existing DVB-T network that is made more dense. New elements: Service system and IP encapsulator.
  Terminal: requires new radio receiver for DVB-H and supporting software

- **Definition:**
  Efficient delivery of point-to-multipoint services for download and streaming. MBMS optimises p-t-p services that are delivered to several receivers simultaneously.
- **Service example:**
  News portal stored in the terminal - updated every hour [each update ca. 500kB].
- **Implementation:**
  Networks: Release 6 software updates required for GGSN, SGSN, RNC and Node-B. New element BM-SC required.
  Terminal: requires new terminals (new software and possibly minor hardware upgrade)

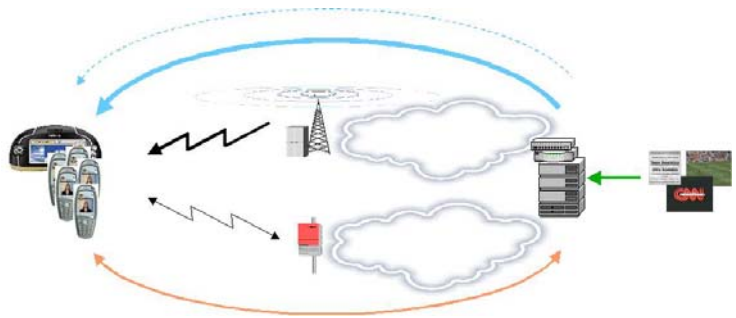
IP Datacasting over DVB-H and other broadcast technologies

	Mobility	Datarate	Frequency band	Comments
DVB-H	High	5 – 31 Mbits/s Typical 10 Mbit/s	UHF (470 – 702 MHz)	
DAB	High	Max 1,15 Mbit/s	VHF	
T-DMB (Korea)	High	Max 1,15 Mbit/s	VHF	
ISDB-T (Japan)	High (one segment)	Max 1,5 Mbit/s Typical 800 kbit/s	VHF + UHF (91 – 770 MHz)	Japan only
DMB-T (China)				
3GPP MBMS (Rel 6)	High	300 kbit/s (multicast)	WCDMA (1920 – 1980 MHz + 2110 – 2170 MHz)	Limited capacity and medium cell size
3GPP2 BCMCS	High	For 1X: 384 kbps (Max) For 1xEV-DO: 204-409 kbps (typical) For future 1XEV-DO (OFDM based): higher than above (TBD)	Many CDMA bands, e.g: 800MHz, 1700MHz Korea), 1900MHz, 2GHz, etc.	
WLAN	Low	Max 11 Mbit/s	2,4 GHz	Small cell size
RDS	High	~100 bit/s	FM – Radio band ~100 MHz	Very low bitrate

Summary and conclusion

Common, open and interoperable

Just the beginning



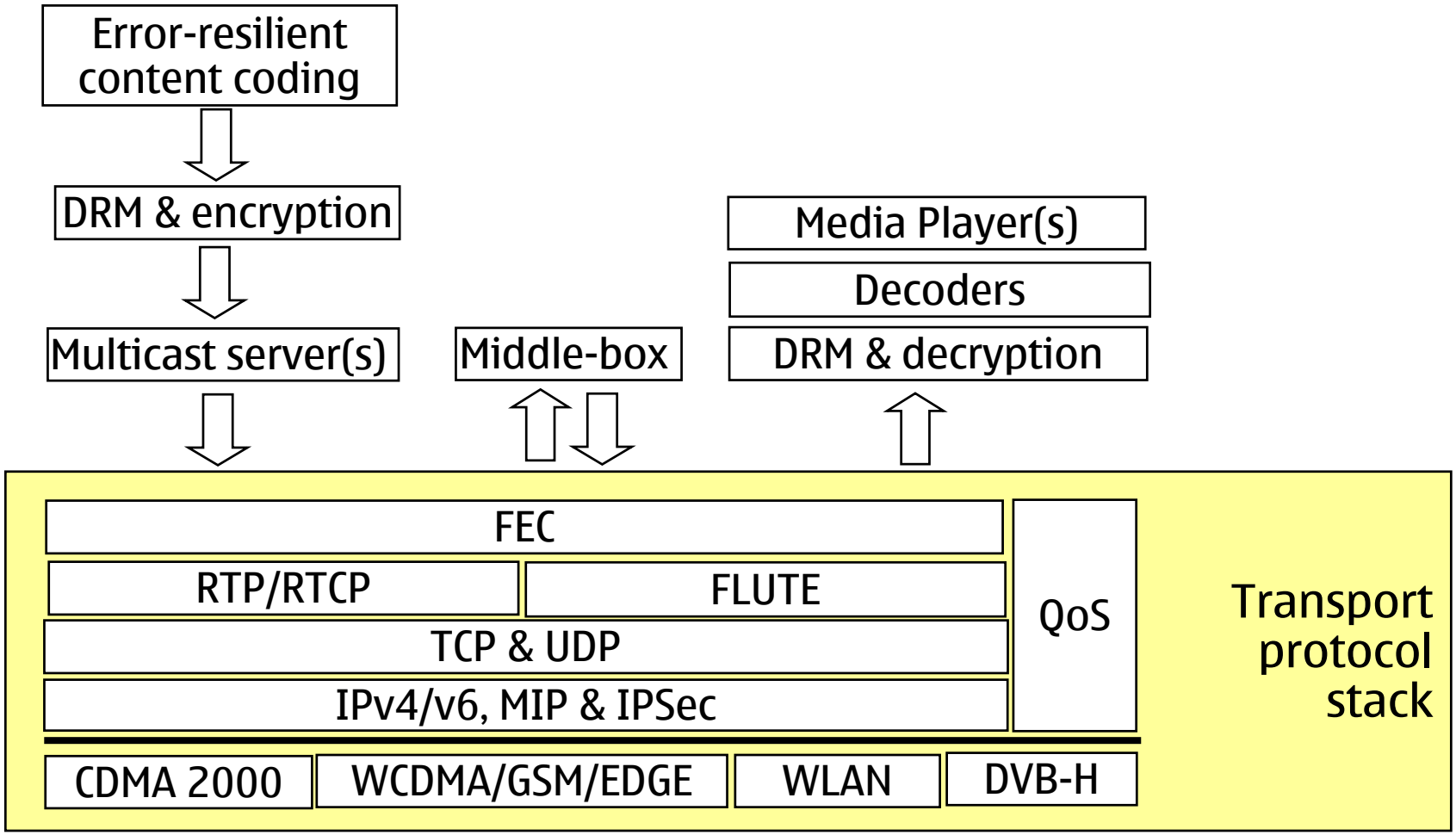
Recap. (1/2)

- This tutorial introduced Mobile Mass Media technology enablers…
- …and the standards-in-progress that will bring interoperability for the mass market
- Mobile Mass Media (MMM) is both the content and delivery for widespread distribution
  - Principally unidirectional broadcast media
  - a convergence of broadcast media, the Internet and Mobile (cellular) communications
- Features of MMM include
  - **Efficient delivery** of the same multimedia content to many people
  - User services based on content **download** and **streaming**

Recap. (2/2)

- Most frequently quoted use cases:
  - Multi-channel MobileTV
  - Digital football stadium
- Making IP Multicast Easy
  - Content delivery using IP Multicast is common to all MMM bearers
  - Routing/switching is trivialised
- The foundations are laid to enable this open and interoperable revolution is in progress

Significant Target: The Target Common MMM Stack



Just the Beginning

- There are opportunities to
  - research technology enablers
  - optimise the end-to-end systems
  - develop applications and services
- Some of the partially undiscovered world:
  - Multicast mobility
  - Reliability optimisations: repair, NxFEC, repetitions
  - Interactivity procedures
  - API families for generalised application development
  - Exciting new applications
  - …
- And the present time is an excellent time to get involved!

Further Information

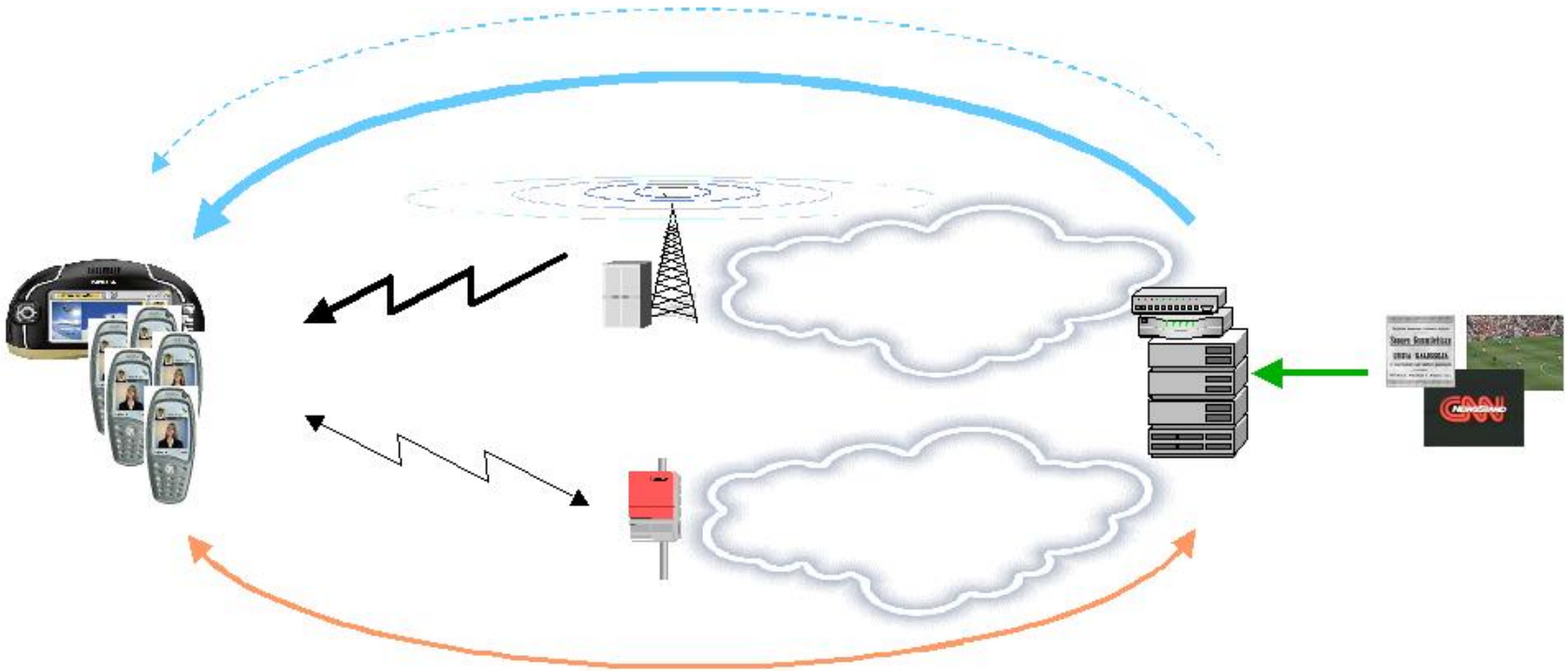
- Rod Walsh
  rod.walsh@nokia.com
  PO Box 100, Tampere, FIN-33721, Finland

- IETF: www.ietf.org
- 3GPP: www.3gpp.org
- 3GPP2: www.3gpp2.org
- OMA: www.openmobilealliance.org
- DVB: www.dvb.org, www.etsi.org

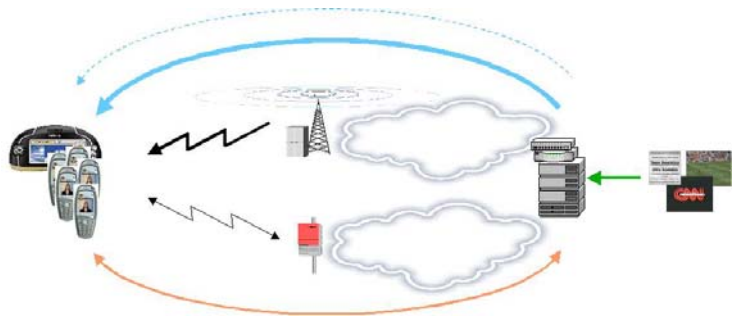
- Book: Content Networking in the Mobile Internet
  Chapter 10: Multicast Content Delivery for Mobiles
  ISBN: 0-471-46618-2
  www.wiley.com/WileyCDA/WileyTitle/productCd-0471466182.html

Thank you!

Questions?

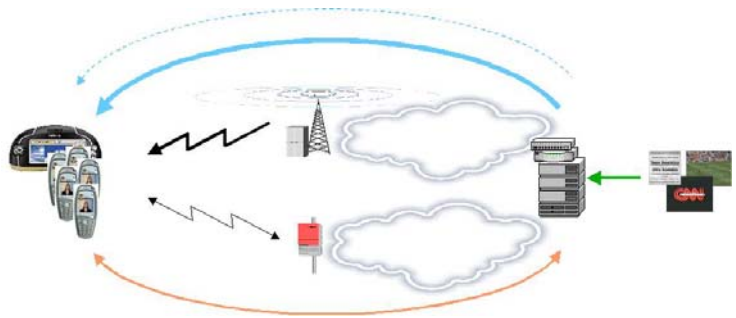


NOKIA

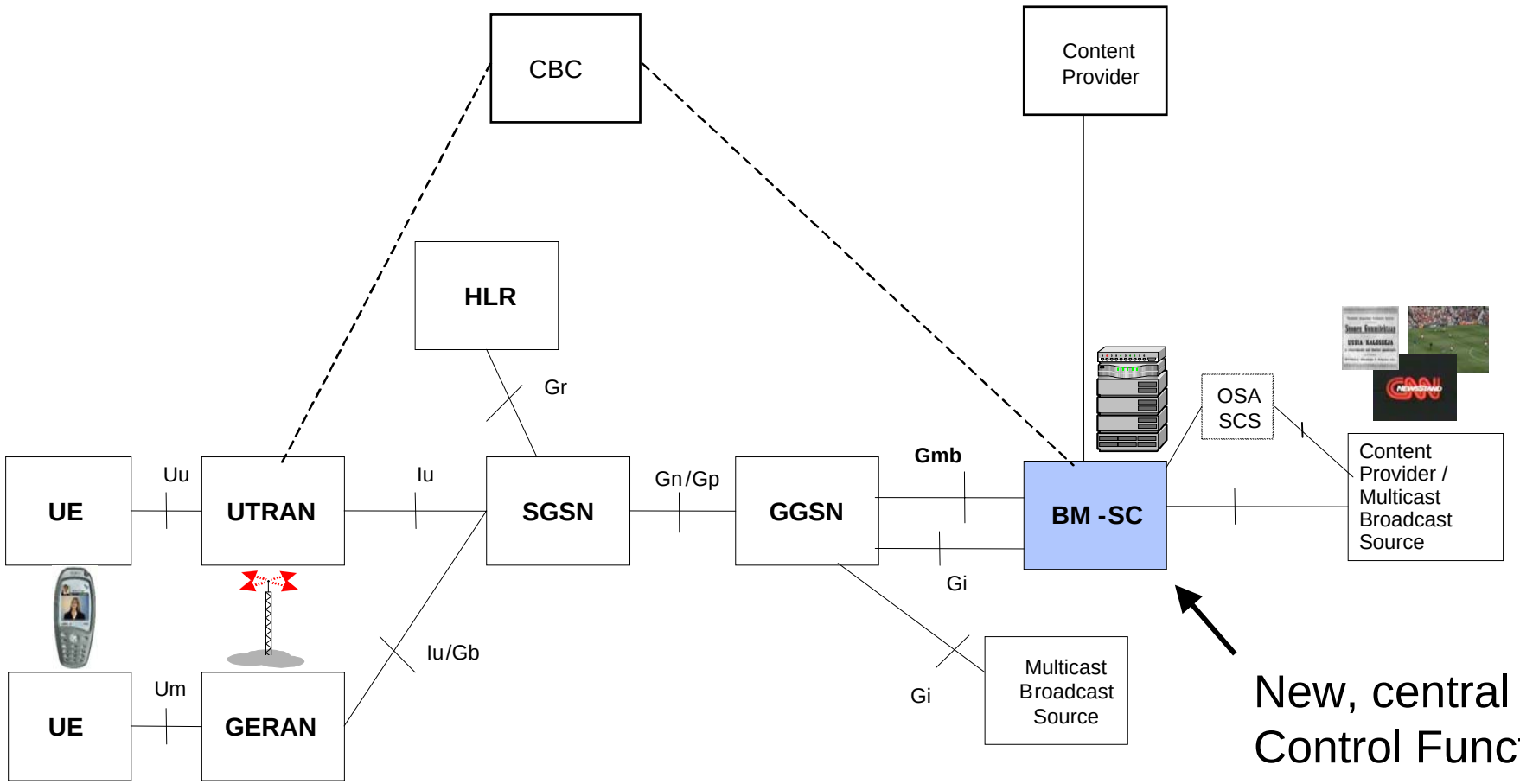


Comparison of MMM Architectures

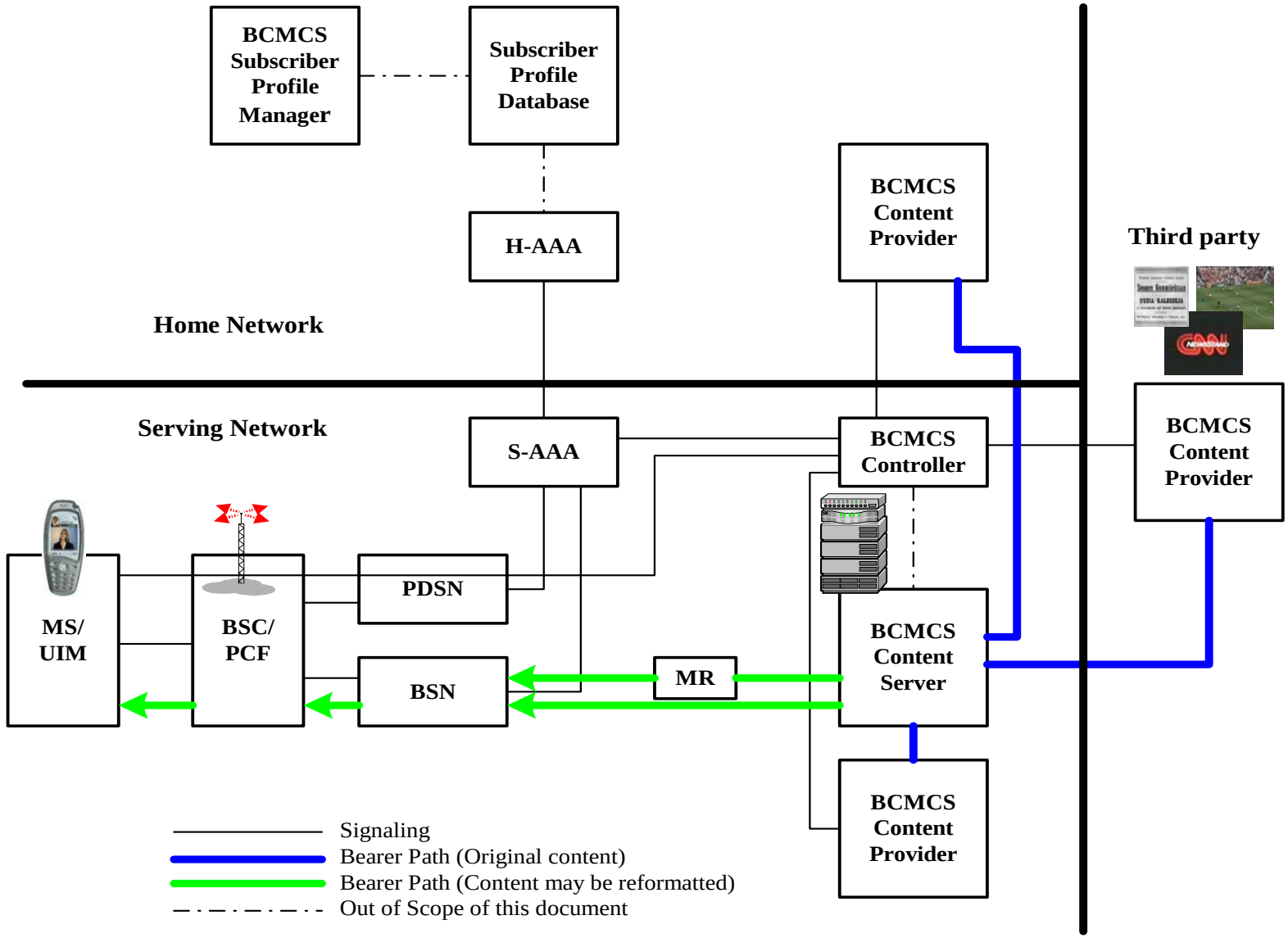
Additional Material



3GPP MBMS Architecture



3GPP2 BCMCS Architecture



DVB “IPDC over DVB-H” architecture

IP Encapsulation Sub-system

DVB-H Network

I_SP1

Service Provisioning Sub-system

I_SM1

I_MT

I_CS2

I_SP3

Service Management Sub-system

Terminal

I_CS1

I_SM2

Commerce Sub-system

I_CS3

I_SP2

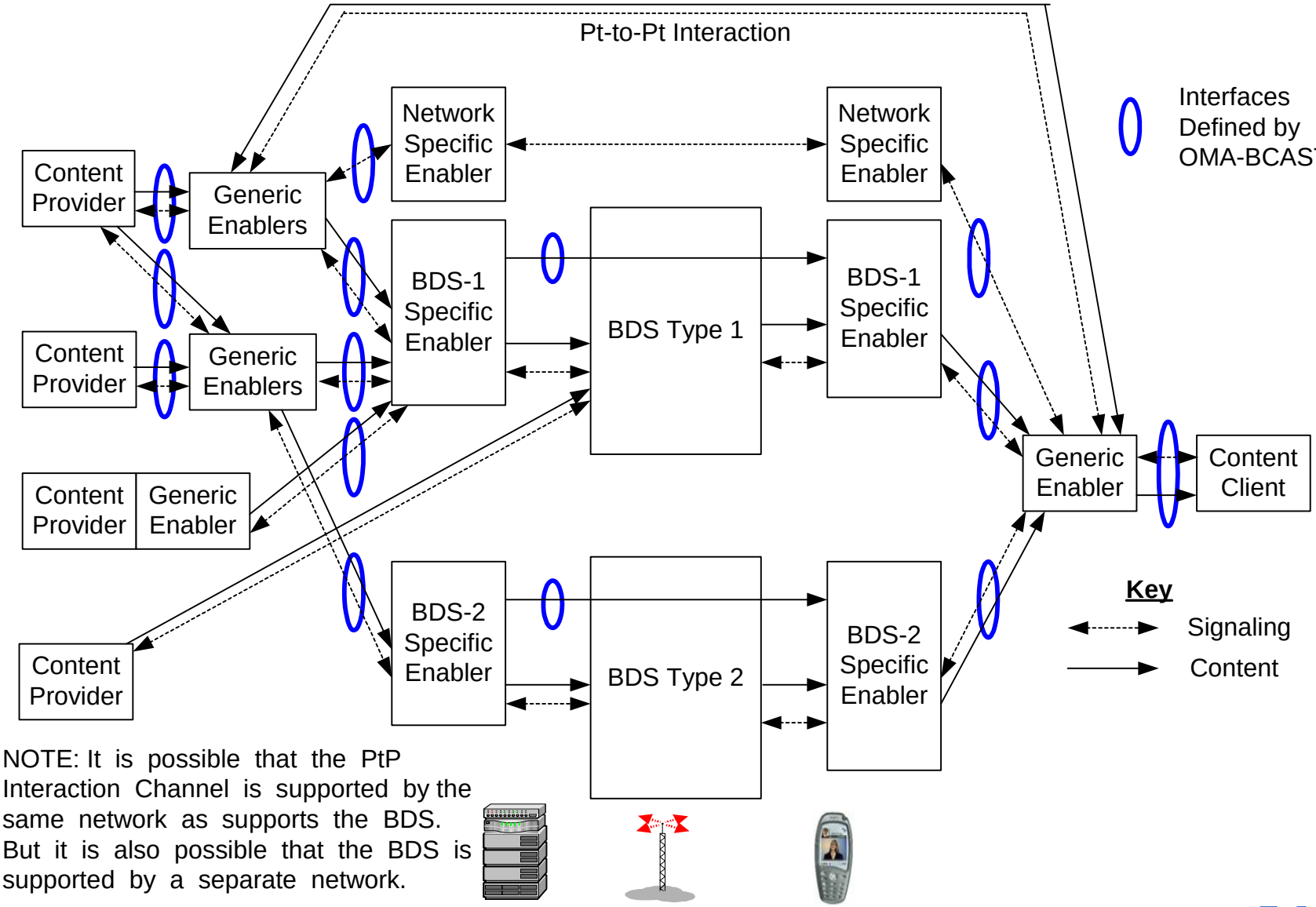
Cellular Core Network

Cellular Access Network

DVB-H

Cellular radio

OMA BCAST High Level Architecture



NOTE: It is possible that the PtP Interaction Channel is supported by the same network as supports the BDS. But it is also possible that the BDS is supported by a separate network.

OMA Service Guide Functional Architecture