



# **N**MOS **A**dvanced **S**treaming **A**rchitecture

# H.264 / H.265 Codecs and more ...

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matrox video



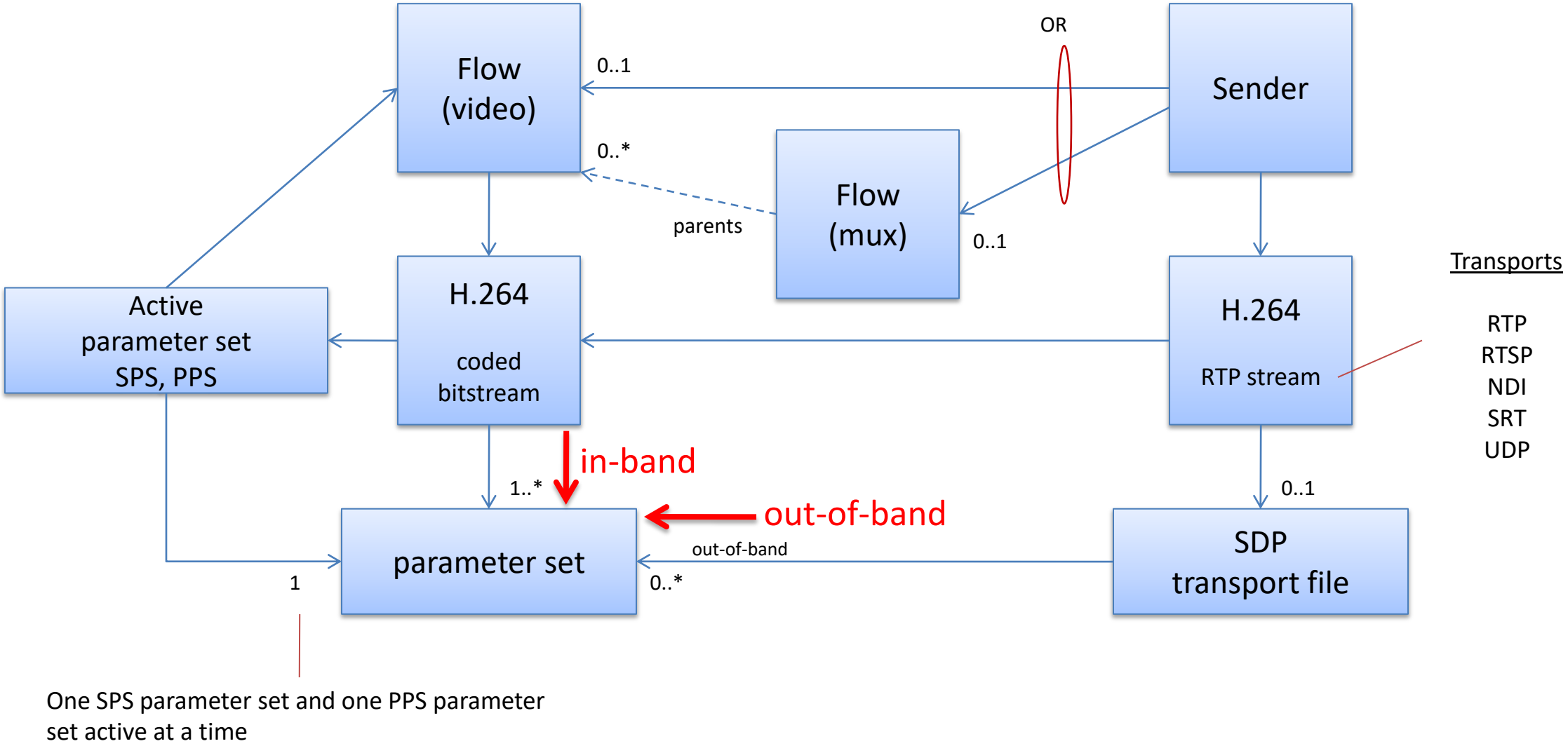
v0.1

# Public GitHub Repository

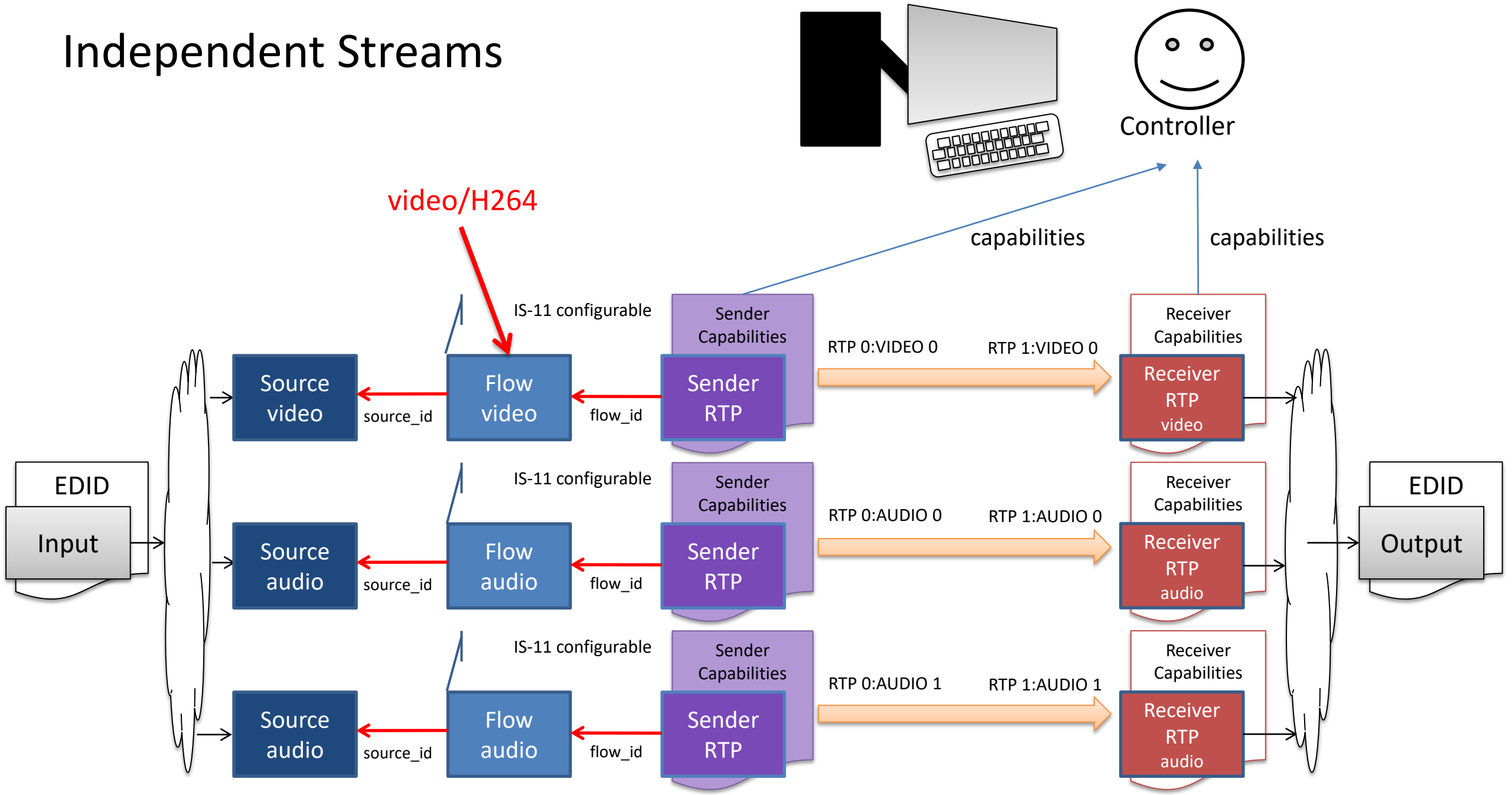
- https://github.com/alabou/NMOS-MatroxOnly
  - README.md

  - NMOS With H.264.md
  - NMOS With H.265.md

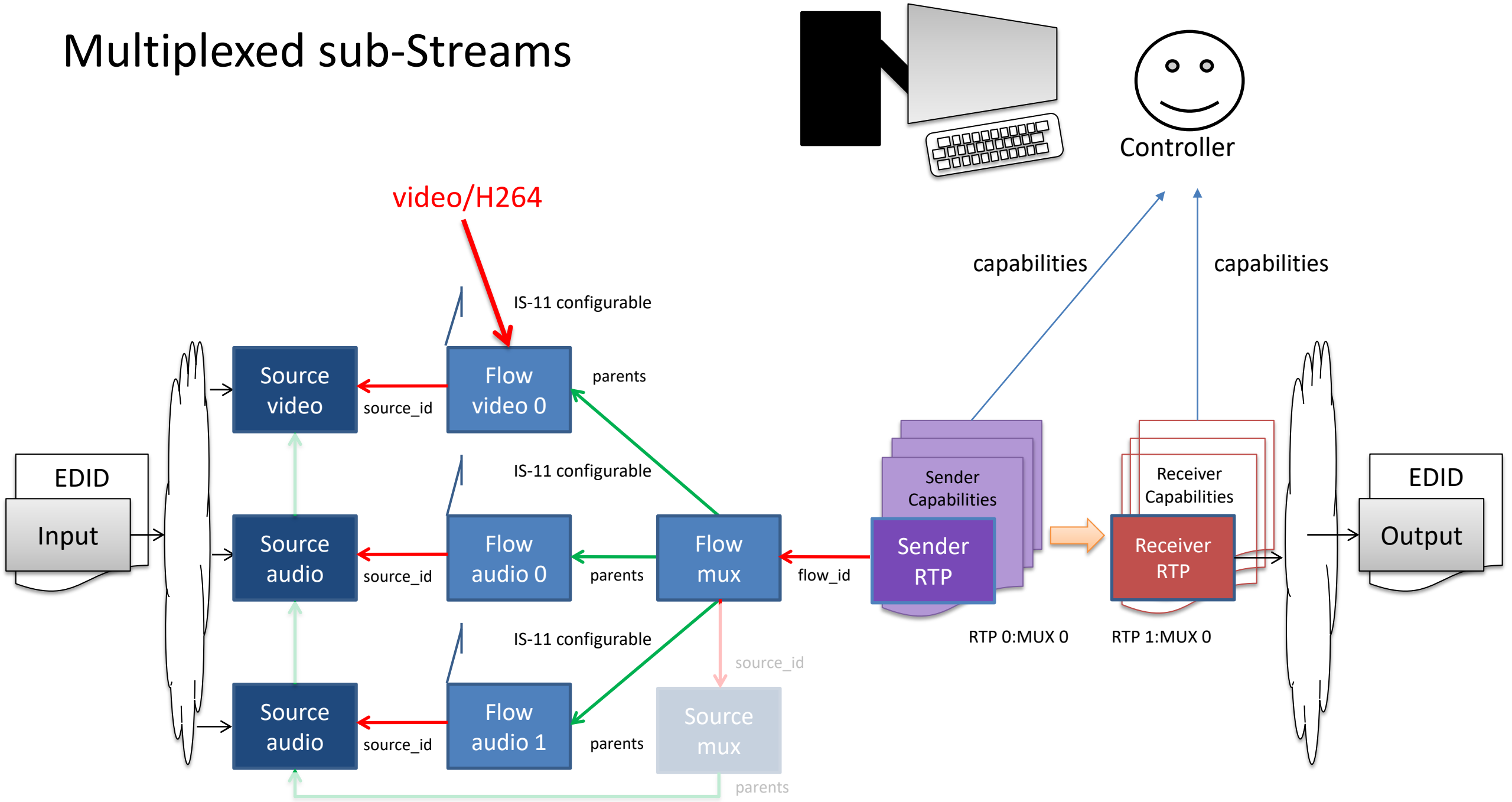
# H.264 Model


Flow
(video)
OR
Sender
0..1
0..*
parents
Flow
(mux)
0..1
Active
parameter set
SPS, PPS
H.264
coded
bitstream
H.264
RTP stream
Transports
RTP
RTSP
NDI
SRT
UDP
in-band
1..*
0..1
out-of-band
parameter set
out-of-band
SDP
transport file
1
0..*
One SPS parameter set and one PPS parameter set active at a time

# Independent Streams



# Multiplexed sub-Streams



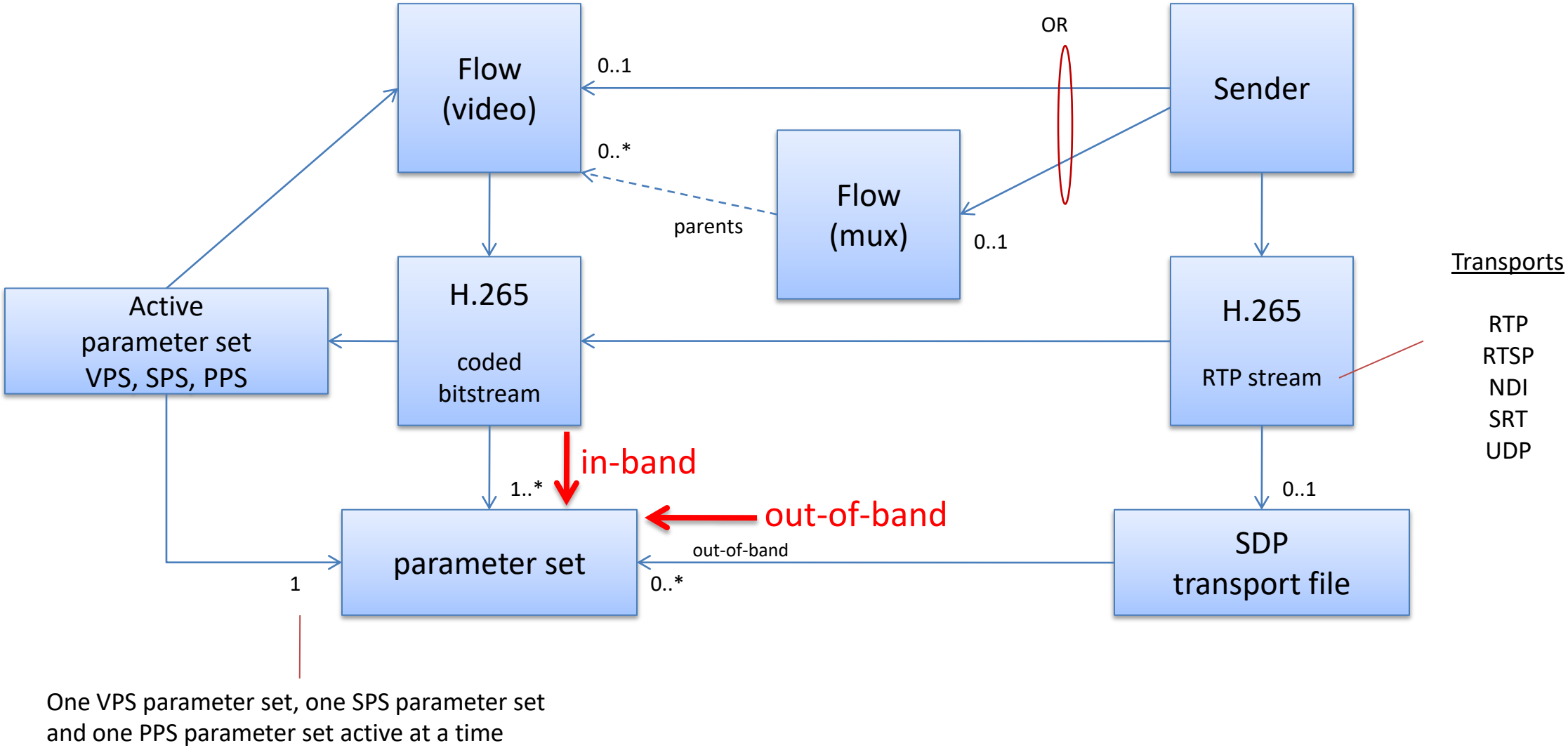
# Definitions H.264

- parameter
  - A syntax element of a sequence parameter set or a picture parameter set.
- picture parameter set (PPS)
  - A *syntax structure containing syntax elements that apply to zero or more entire coded pictures as determined by the pic_parameter_set_id syntax element found in each slice header.*
- sequence parameter set (SPS)
  - A *syntax structure containing syntax elements that apply to zero or more entire coded video sequences as determined by the content of a seq_parameter_set_id syntax element found in the picture parameter set referred to by the pic_parameter_set_id syntax element found in each slice header.*
  - *VUI (Video Usability Information is part of the SPS*

# Active Parameter Set

- **active** parameter set
  - SPS and PPS currently in use by the bitstream
    - Slice header reference PPS pic_parameter_set_id that reference SPS seq_parameter_set_id
  - parameters values
    - Some derive from the associated Flow attributes
    - Some are not associated with the Flow attributes

# H.265 Model


Flow
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H.265
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VPS, SPS, PPS
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parameter set
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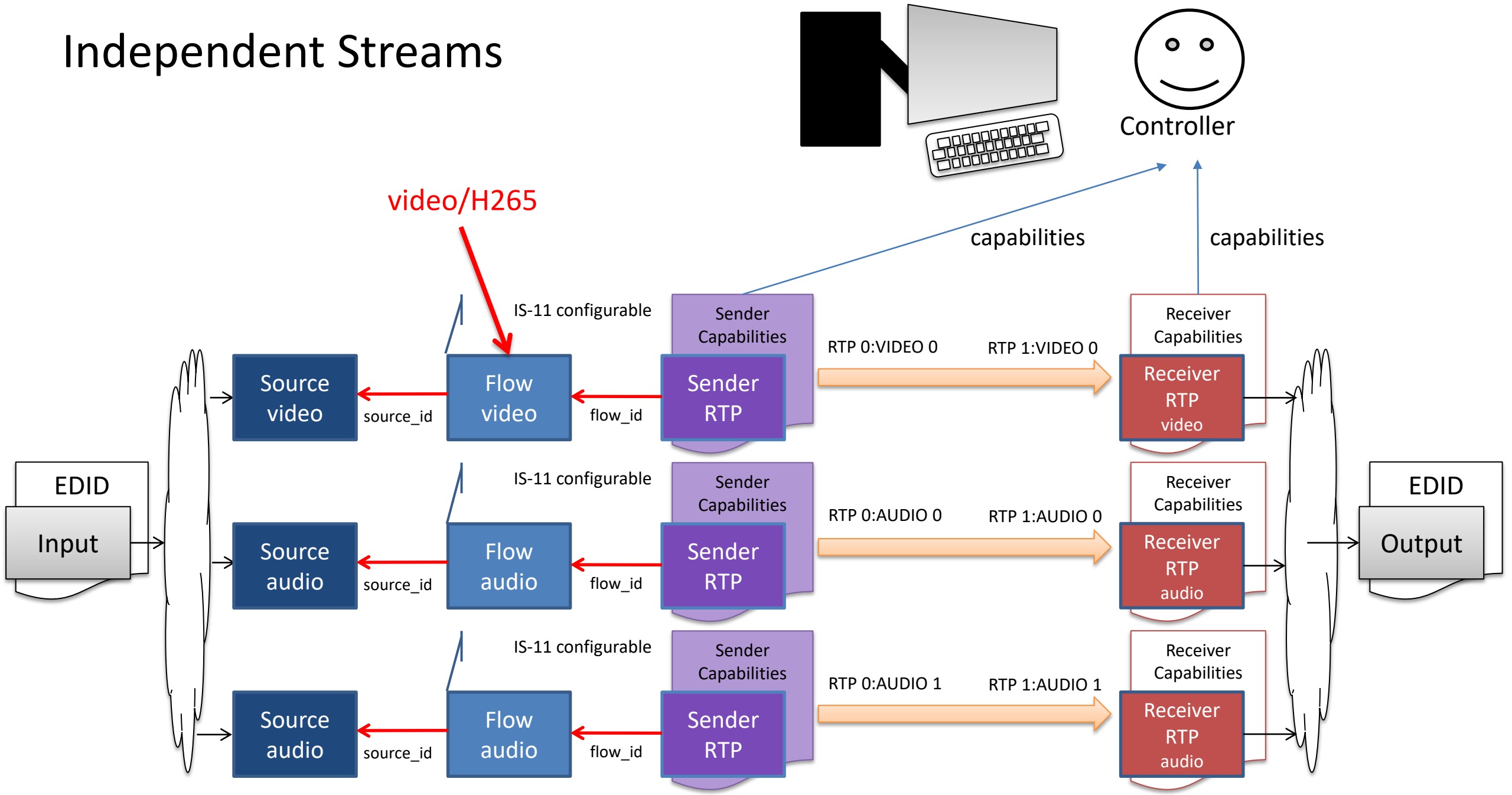
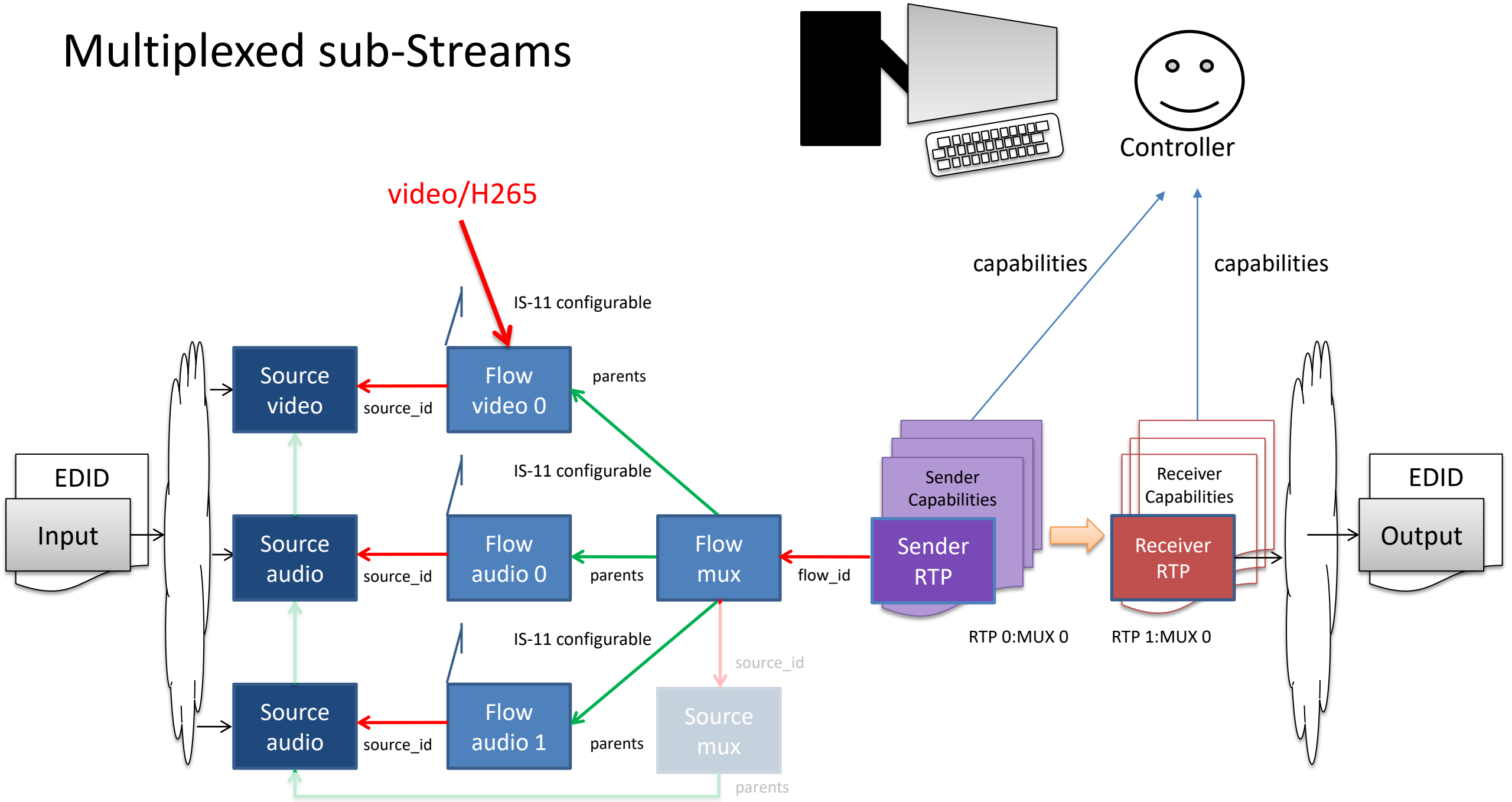
SDP
transport file
One VPS parameter set, one SPS parameter set
and one PPS parameter set active at a time

# Independent Streams



# Multiplexed sub-Streams



# Definitions H.265

- parameter
  - A syntax element of a video parameter set (VPS), sequence parameter set (SPS) or picture parameter set (PPS)
- picture parameter set (PPS)
  - *A syntax structure containing syntax elements that apply to zero or more entire coded pictures as determined by a syntax element found in each slice segment header.*
- sequence parameter set (SPS)
  - *A syntax structure containing syntax elements that apply to zero or more entire CVSs as determined by the content of a syntax element found in the PPS referred to by a syntax element found in each slice segment header.*
  - *VUI (Video Usability Information is part of the SPS*
- *video parameter set (VPS)*
  - *A syntax structure containing syntax elements that apply to zero or more entire CVSs as determined by the content of a syntax element found in the SPS referred to by a syntax element found in the PPS referred to by a syntax element found in each slice segment header.*

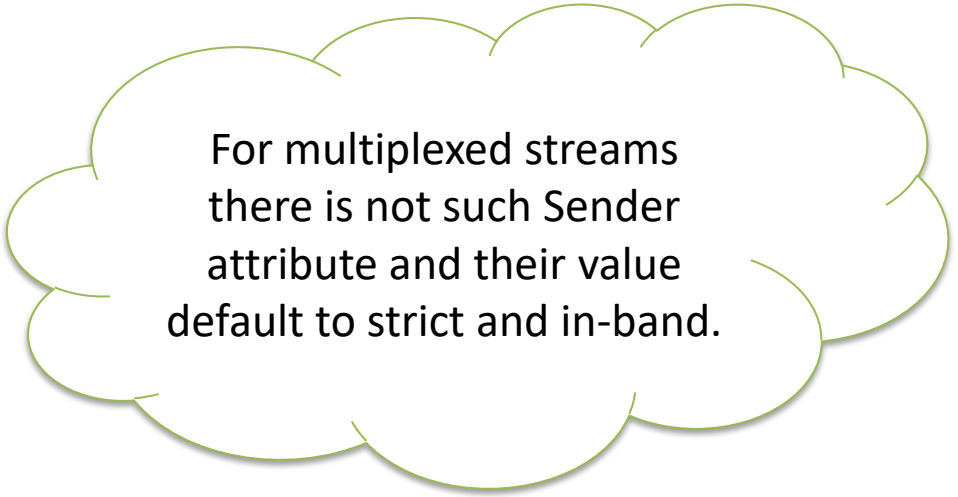
# Active Parameter Set

- **active** parameter set
  - VPS, SPS and PPS currently in use by the bitstream
    - Slice header reference PPS pic_parameter_set_id that reference SPS seq_parameter_set_id that reference VPS video_parameter_set_id
  - parameters values
    - Some derive from the associated Flow attributes
    - Some are not associated with the Flow attributes

# Model's Parameters => Sender attributes

- parameter_sets_flow_mode
  - strict ( default )
  - static
  - dynamic

- parameter_sets_transport_mode
  - in_band ( default )
  - out_of_band
  - in_and_out_of_band



# Flow attributes => VPS, SPS, PPS

| Flow attribute | VPS | SPS | PPS |
|---|---|---|---|
| profile | x | x | |
| level | x | x | |
| frame_width | | x | slices, tiles |
| frame_height | | x | slices, tiles |
| grain_rate | x | x | |
| components | | x | |
| colorspace | | x | |
| transfer_characteristic | | x | |
| interlace_mode | x | x | |
| bit_rate | x | x | |
| constant_bit_rate | x | x | |

# “strict” Flow (1 VPS, 1 SPS, many PPS)

| Flow attribute | Requirement |
|---|---|
| profile | constant |
| level | constant |
| frame_width | constant |
| frame_height | constant |
| grain_rate | constant |
| components | constant |
| colorspace | constant |
| transfer_characteristic | constant |
| interlace_mode | constant |
| bit_rate | constant |
| constant_bit_rate | constant |

# “strict” Flow (**1** VPS, **1** SPS, many PPS)

- The Flow attributes are constant
  - All the VPS and SPS parameters are constant
    - At most one VPS and at most one SPS
  - The PPS parameters associated to Flow attributes are constant
    - Many PPS
  - Encoder and Flow are restricted

# “static” Flow (**many** VPS, **many** SPS, many PPS)

| Flow attribute | Requirement |
|---|---|
| profile | constant |
| level | constant |
| frame_width | constant |
| frame_height | constant |
| grain_rate | constant |
| components | constant |
| colorspace | constant |
| transfer_characteristic | constant |
| interlace_mode | constant |
| bit_rate | **variable** } To allow adaptive bit_rate scenarios |
| constant_bit_rate | constant |

# “static” Flow (**many** VPS, **many** SPS, many PPS)

- The Flow attributes **except** bit_rate are constant
  - The VPS, SPS, PPS parameters associated to Flow attributes **except** bit_rate are constant
    - Many VPS, many SPS and many PPS
  - Encoder is unrestricted
  - Flow is restricted

# “dynamic” Flow (**many** VPS, **many** SPS, many PPS)

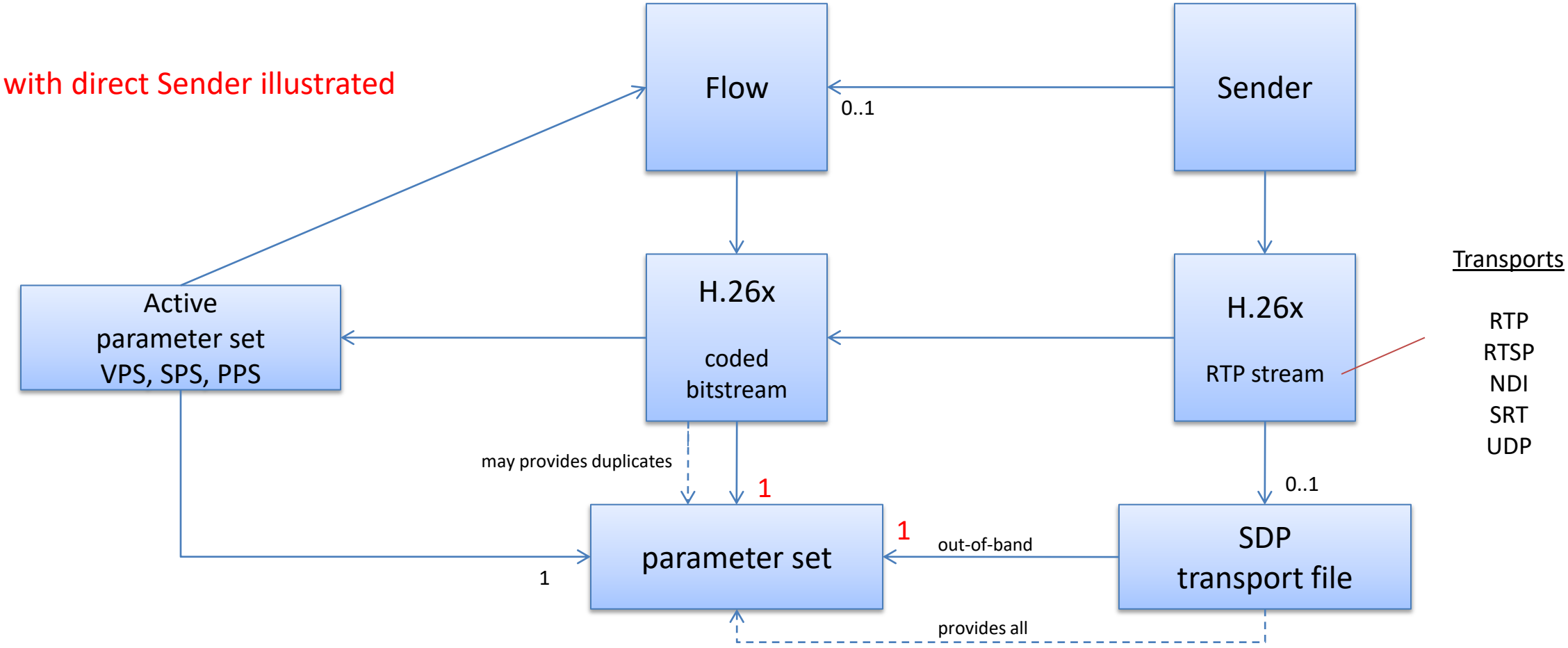
| Flow attribute | Requirement |
|---|---|
| profile | variable |
| level | variable |
| frame_width | variable |
| frame_height | variable |
| grain_rate | variable |
| components | variable |
| colorspace | variable |
| transfer_characteristic | variable |
| interlace_mode | variable |
| bit_rate | variable |
| constant_bit_rate | variable |

# “dynamic” Flow (**many** VPS, **many** SPS, many PPS)

- All the Flow attributes are dynamic
  - All the VPS, SPS and PPS parameters are dynamic
    - Many VPS, many SPS and many PPS
  - Encoder and Flow are unrestricted

# H.26x Model (out-of-band, strict-Flow)

Example with direct Sender illustrated




1: At most one VPS and SPS and a number of PPS referencing the one SPS

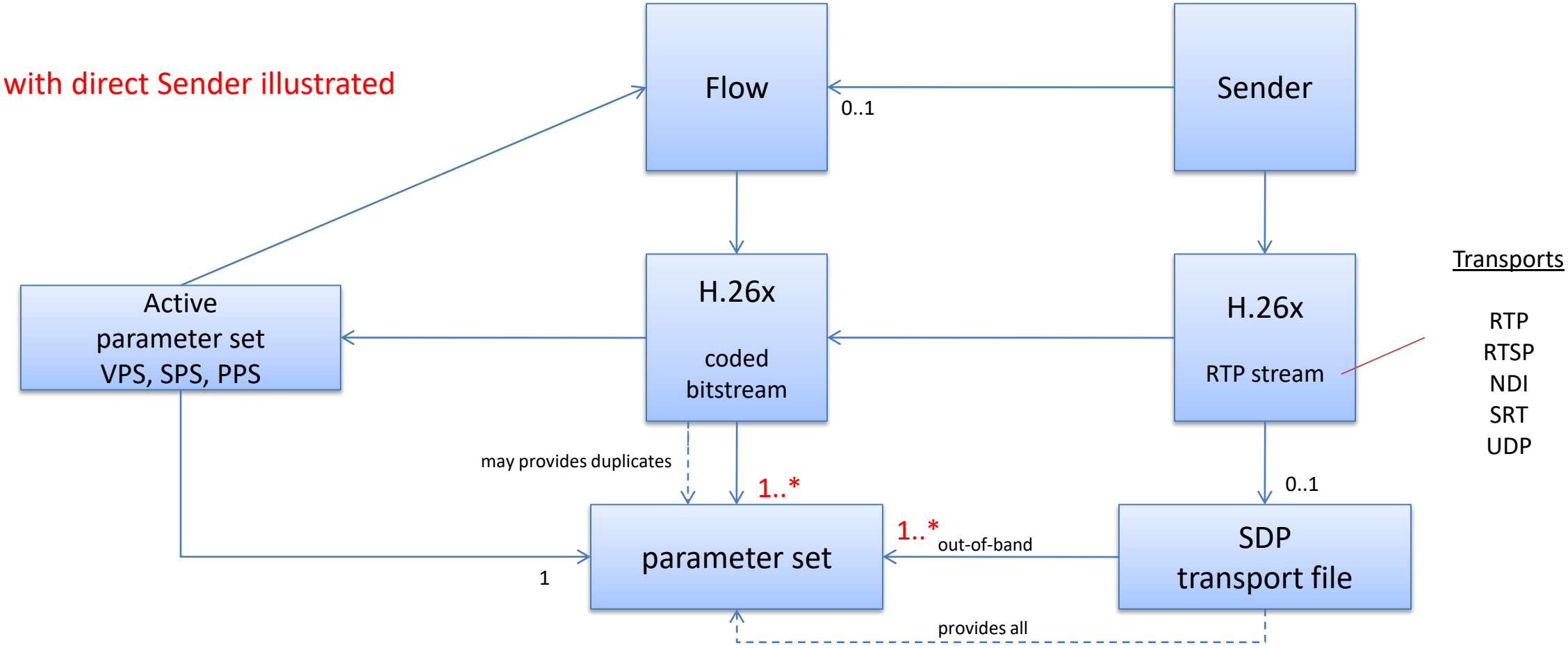
# out-of-band, **strict-Flow**

- H.264, H.265 bitstream
  - Uses at most one VPS, one SPS and a number of PPS
    - provided out-of-band
    - parameters of VPS are constant
    - parameters of SPS are constant
    - parameters of PPS associated to Flow attributes are constant
  - May transport “duplicate” in-band parameter sets
    - Fully matching out-of-band parameter sets

- When Flow attributes change => SDP transport file changes
- When VPS, SPS parameters change => SDP transport file changes
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

# H.26x Model (out-of-band, static-Flow)

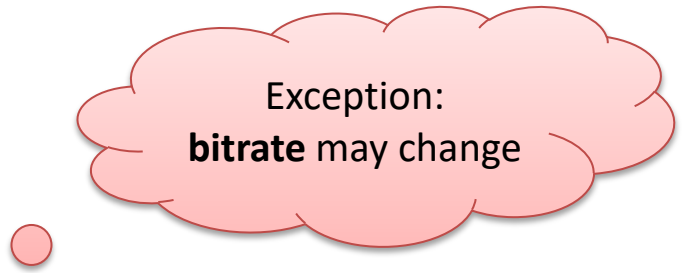
Example with direct Sender illustrated




1: The VPS, SPS and PPS parameters associated to Flow attributes are constant

# out-of-band, **static-Flow**

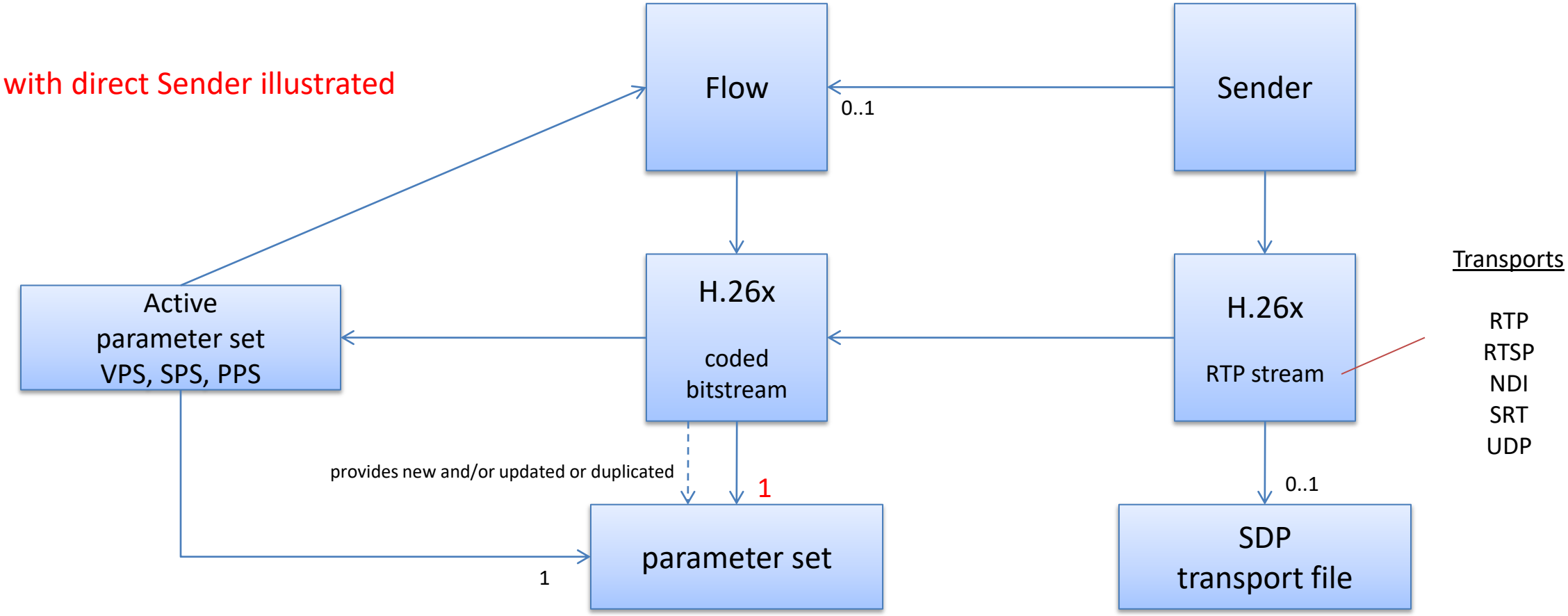
- H.264, H.265 bitstream
  - Uses parameter sets associated to at most one Flow
    - provided out-of-band
    - parameters of VPS associated to Flow attributes are constant
    - parameters of SPS associated to Flow attributes are constant
    - parameters of PPS associated to Flow attributes are constant
  - May transport “duplicate” in-band parameter sets
    - Fully matching out-of-band parameter sets




- When Flow attributes change => SDP transport file changes
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

# H.26x Model (in-band, strict-Flow)

Example with direct Sender illustrated




1: At most one VPS, one SPS and a number of PPS referencing the one SPS

# in-band, **strict-Flow**

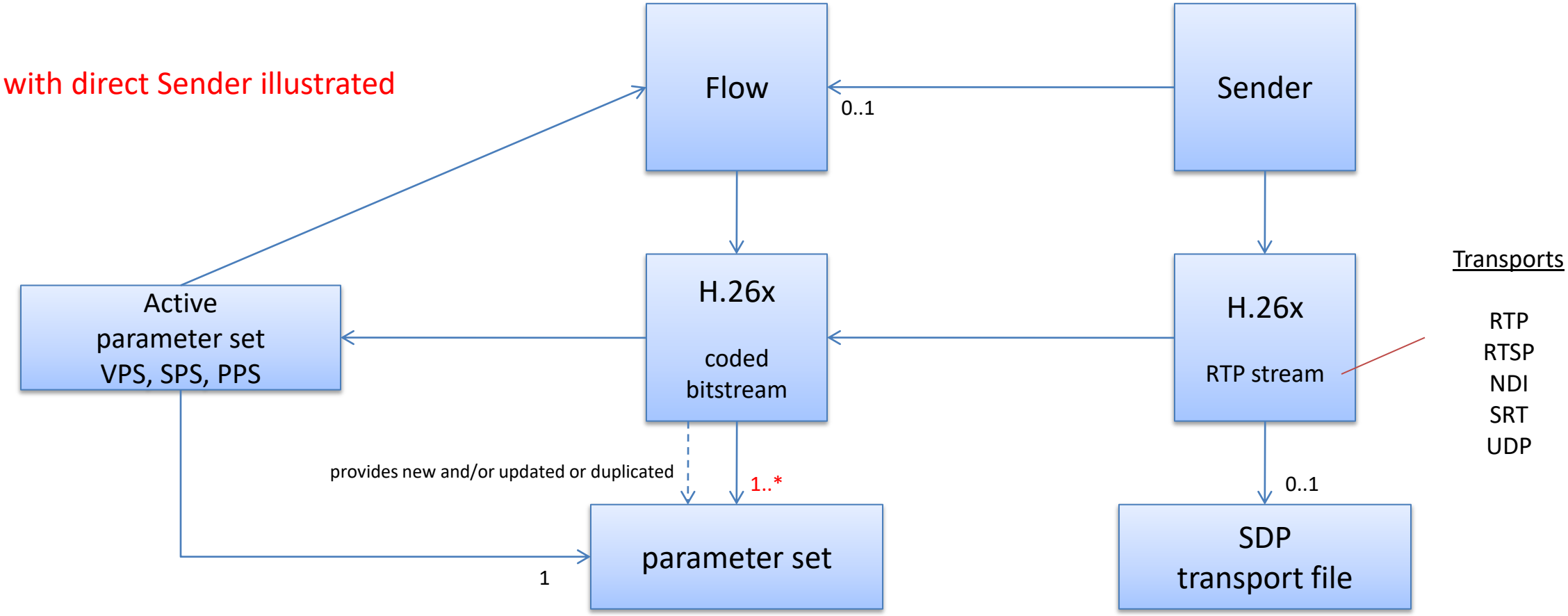
- H.264, H.265 bitstream
  - Uses at most one SPS and a number of PPS
    - provided in-band or in-and-out-of-band
    - parameters of VPS are constant
    - parameters of SPS are constant
    - parameters of PPS associated to Flow attributes are constant
  - May transport in-band parameter sets
    - “new” or “duplicated” VPS, SPS, PPS

- When Flow attributes change => SDP transport file changes
- When VPS, SPS parameters change => SDP transport file changes
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

When in-band parameter sets are used, the SDP transport file must at least change its version to indicate a change of Flow or SPS and be compliant with the strict-Flow mode.

# H.26x Model (in-band, static-Flow)

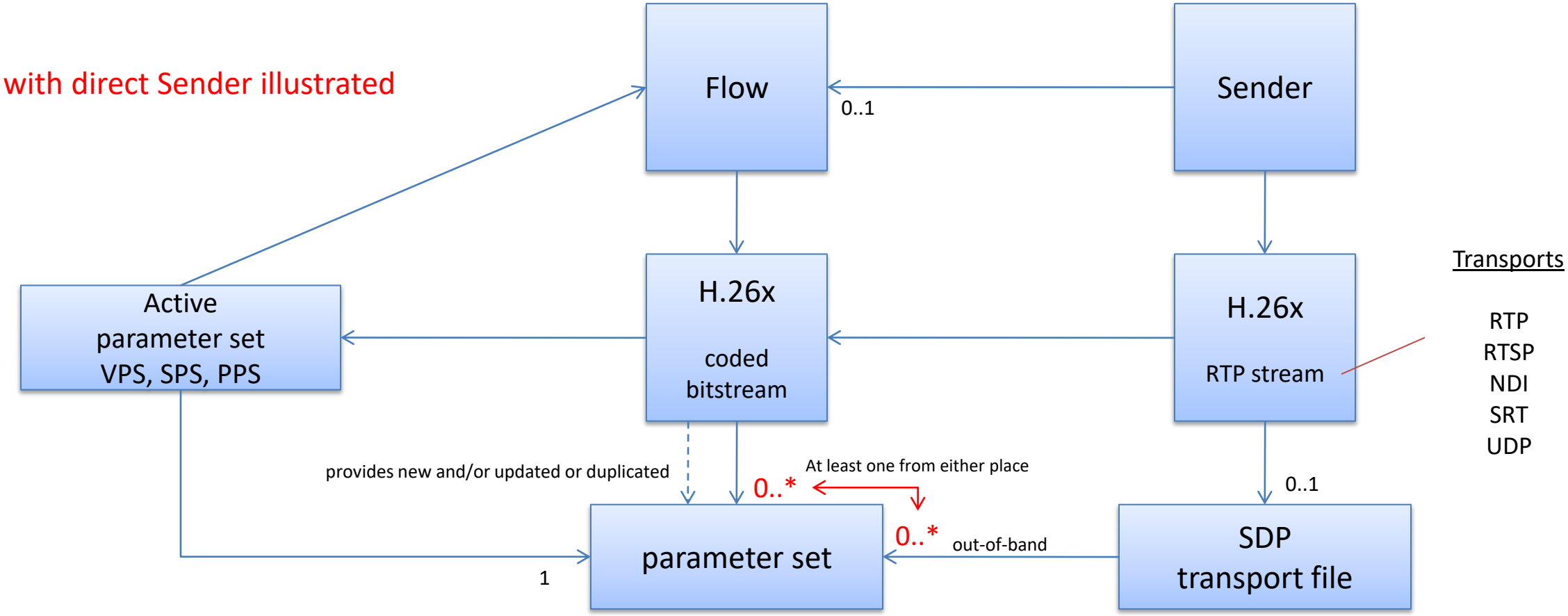
Example with direct Sender illustrated




1: The VPS, SPS and PPS parameters associated to Flow attributes are constant

# H.26x Model (in-and-out-of-band, static-Flow)

Example with direct Sender illustrated




1: The VPS, SPS and PPS parameters associated to Flow attributes are constant

# in-band or in-and-out-of-band, **static-Flow**

Exception: **bitrate** may change

- H.264, H.265 bitstream
  - Uses parameter sets associated to at most one Flow
    - provided in-band or in-and-out-of-band
    - parameters of VPS associated to Flow attributes are constant
    - parameters of SPS associated to Flow attributes are constant
    - parameters of PPS associated to Flow attributes are constant
  - May transport in-band parameter sets
    - “new”, “updated” or “duplicated” (constant Flow attributes)

- When Flow attributes change => SDP transport file changes
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

When in-band parameter sets are used, the SDP transport file must at least change its version to indicate a change of Flow or SPS and be compliant with the strict-Flow mode.

# Dynamic-Flow

IPMX has info_block are more powerful as SDP parameter may change.

- Advanced feature
  - Simple example:
    - Dynamic W x H x GrainRate changes
      - without streaming interruption !!!
      - without involving the Controller !!!
  - Possible with H.264/H.265 parameter sets
    - VPS, SPS contains pic_width, pic_height, …
- SDP transport file not tracking the current Flow for the following attributes:
  - profile, level, frame_width, frame_height, grain_rate, components, colorspace, transfer_characteristic, interlace_mode, bit_rate, constant_bit_rate

After the Sender activation

# Dynamic-Flow

- The SDP transport file content does NOT change
  - still valid as-is for the Receivers
    - Parameters provided to the Receivers
      - Through many initial out-of-band VPS, SPS, PPS
      - Through new additional in-band VPS, SPS, PPS

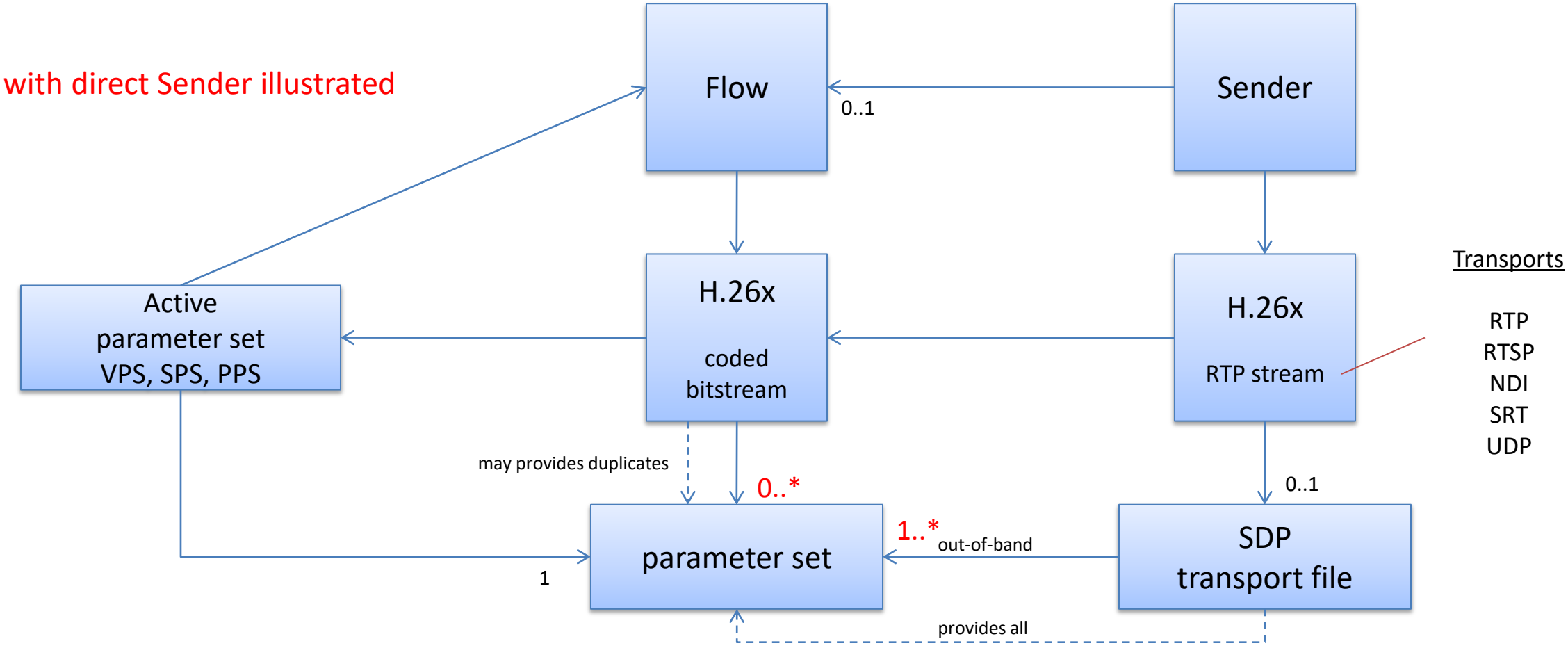
or any combination of the two modes

  - Receivers adapt to new parameters dynamically
  - Controller
    - knows about Sender operating in dynamic Flow mode
    - Knows about Receivers supporting dynamic Flow mode
    - even if Sender's version and/or associated Flow's version have changed
      - do not have to re-PATCH the Receivers if it is active

The Receiver does not know if the Sender operates in dynamic, static or strict mode.

# H.26x Model (out-of-band, dynamic-Flow)

Example with direct Sender illustrated




1..*: The VPS, SPS and PPS parameters associated to Flow attributes are dynamic and may change

# out-of-band, **dynamic-Flow**

- H.264, H.265 bitstream
  - May use parameter sets associated to multiple Flows
    - provided out-of-band
    - some parameters associated to Flow attributes are dynamic and may change
  - May transport “duplicate” in-band parameter sets
    - Fully matching out-of-band parameter sets
- When selected Flow attributes change

  => Active parameter set changes

  - among those received out-of-band

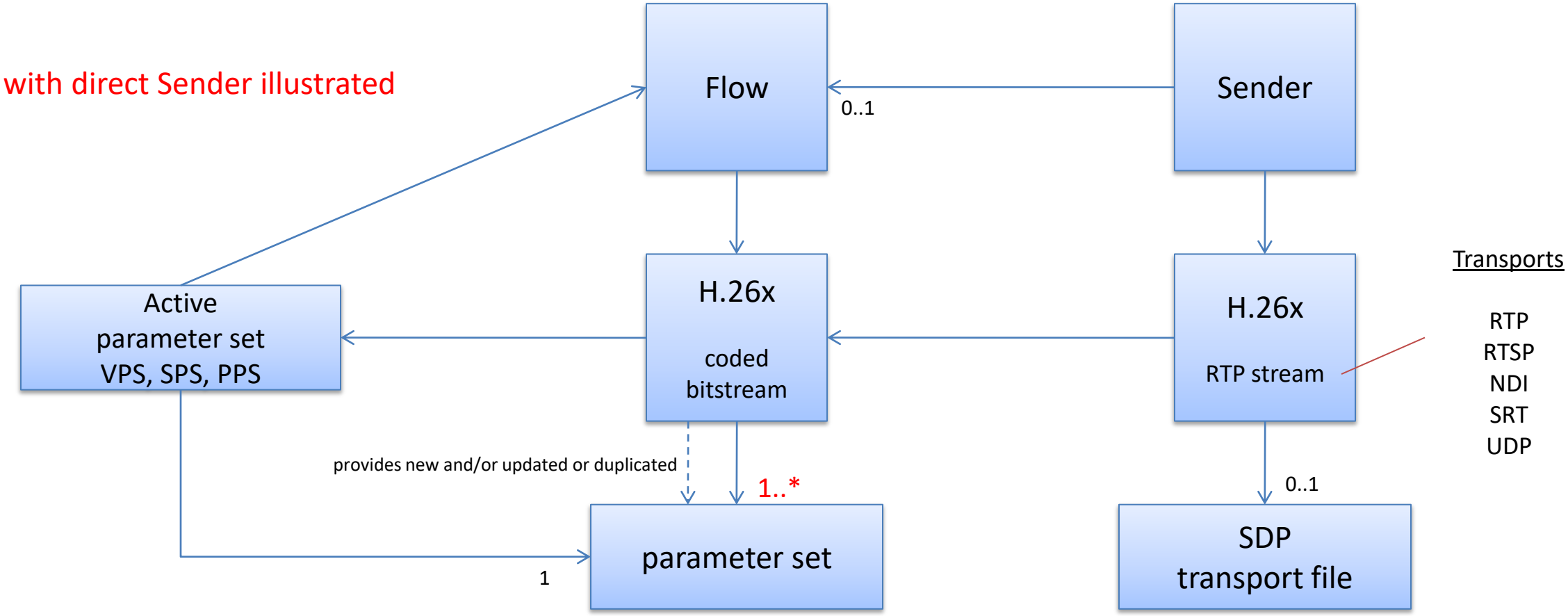
  => SDP file does NOT changes

  - otherwise not compatible with dynamic-Flow
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

| dynamic Flow attribute |
| --- |
| profile |
| level |
| frame_width |
| frame_height |
| grain_rate |
| components |
| colorspace |
| transfer_characteristic |
| interlace_mode |
| bit_rate |
| constant_bit_rate |

# H.26x Model (in-band, dynamic-Flow)

Example with direct Sender illustrated

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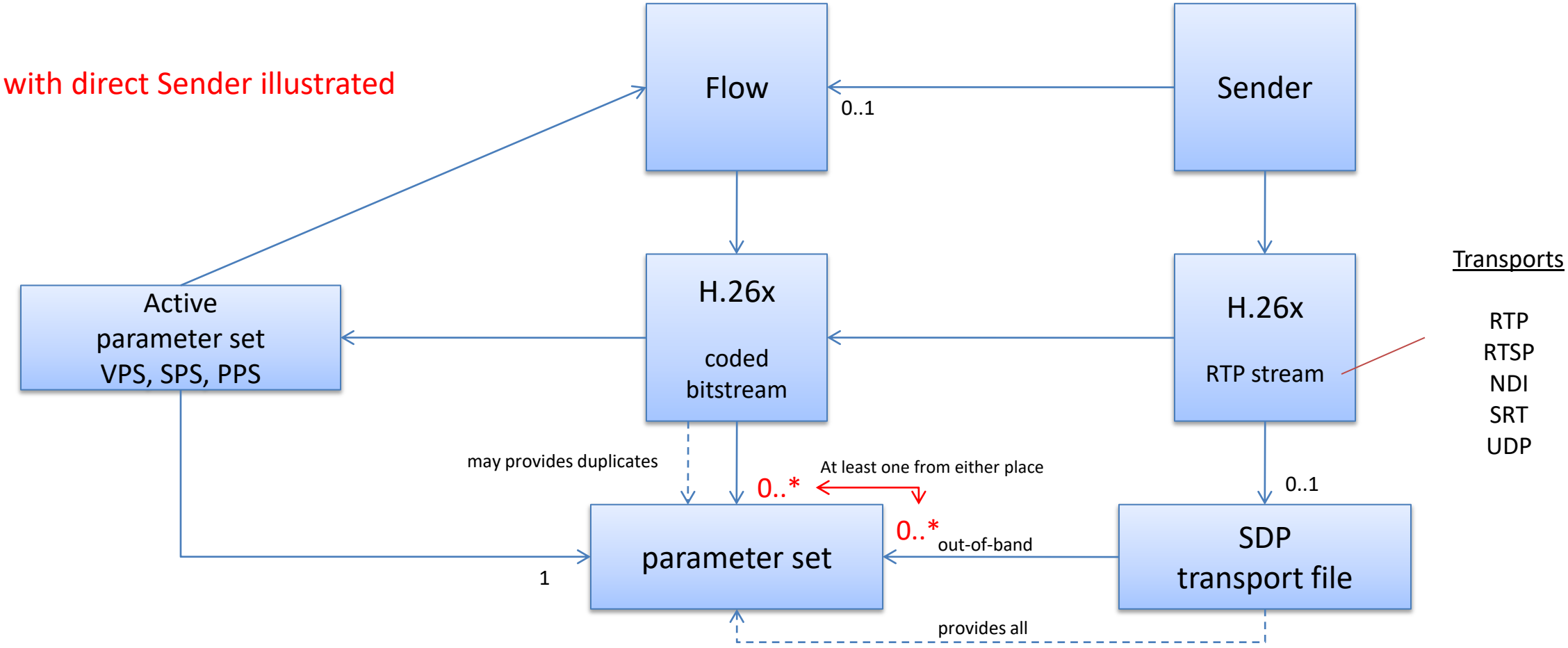
# H.26x Model (in-and-out-of-band, dynamic-Flow)

Example with direct Sender illustrated




1..*: The VPS, SPS and PPS parameters associated to Flow attributes are dynamic and may change

# in-band, in-and-out-of-band, **dynamic-Flow**

- H.264, H.265 bitstream
  - May use parameter sets associated to multiple Flows
    - provided in-band or in-and-out-of-band
    - some parameters associated to Flow attributes are dynamic and may change
  - May transport in-band parameter sets
    - “new”, “updated” or “duplicated”
- When selected Flow attributes change

  => Active parameter set changes

  - among those received in-band or in-and-out-of-band

  => SDP file does NOT changes

  - otherwise not compatible with dynamic-Flow
  - Behaviour as per IS-05, IS-04, IS-11
    - Notification of Flow changes
    - Notification of Sender changes

| dynamic Flow attribute |
| --- |
| profile |
| level |
| frame_width |
| frame_height |
| grain_rate |
| components |
| colorspace |
| transfer_characteristic |
| interlace_mode |
| bit_rate |
| constant_bit_rate |

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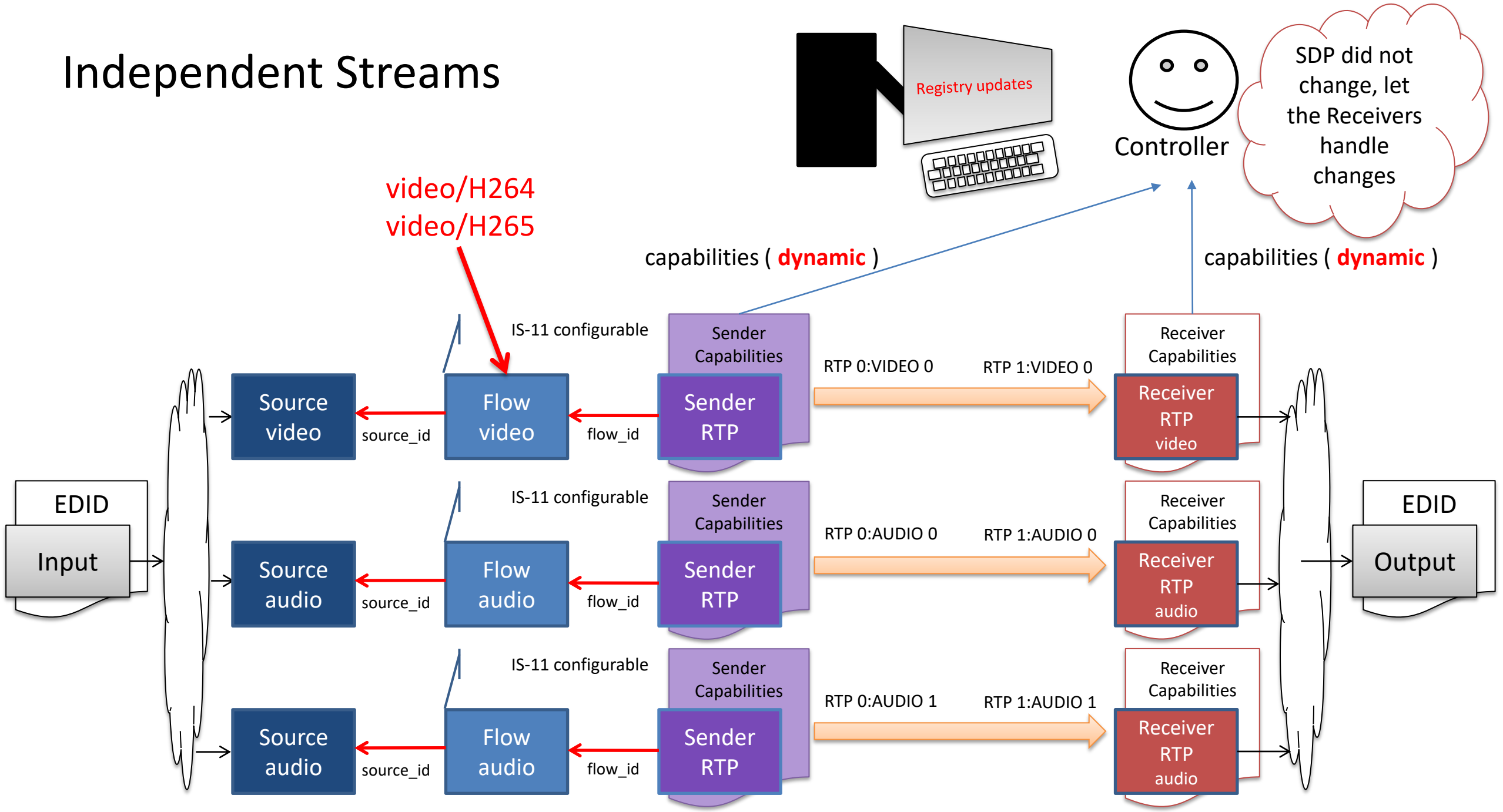
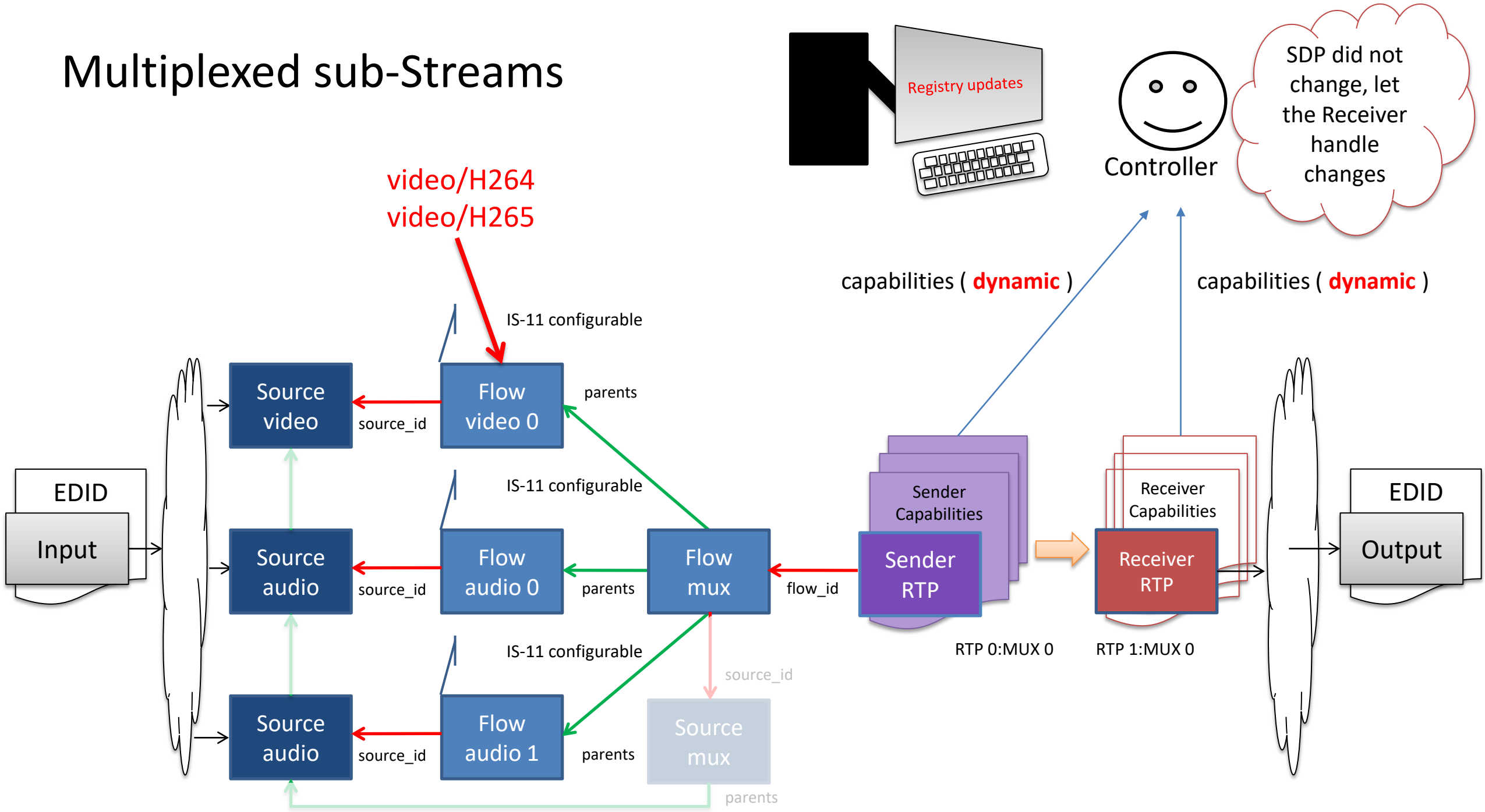


# Multiplexed sub-Streams



# H.264 Profiles

| H.264 Profiles (partial list) | |
|---|---|
| "BaselineConstrained", "Baseline" | "Extended" |
| "Main" | |
| "High", "HighProgressive", "HighConstrained" | |
| "High10", "High10Progressive", "High-422" | "HighPredictive-444" |
| "High10Intra", "HighIntra-422" | "HighIntra-444" , "CAVLCIntra-444" |

- H.264 offer many profiles for various compression use-cases:
  - intra and inter coding algorithms
  - 4:2:0, 4:2:2 and 4:4:4 color sampling
  - 8, 10 or 12 bit per component

# H.265 Profiles

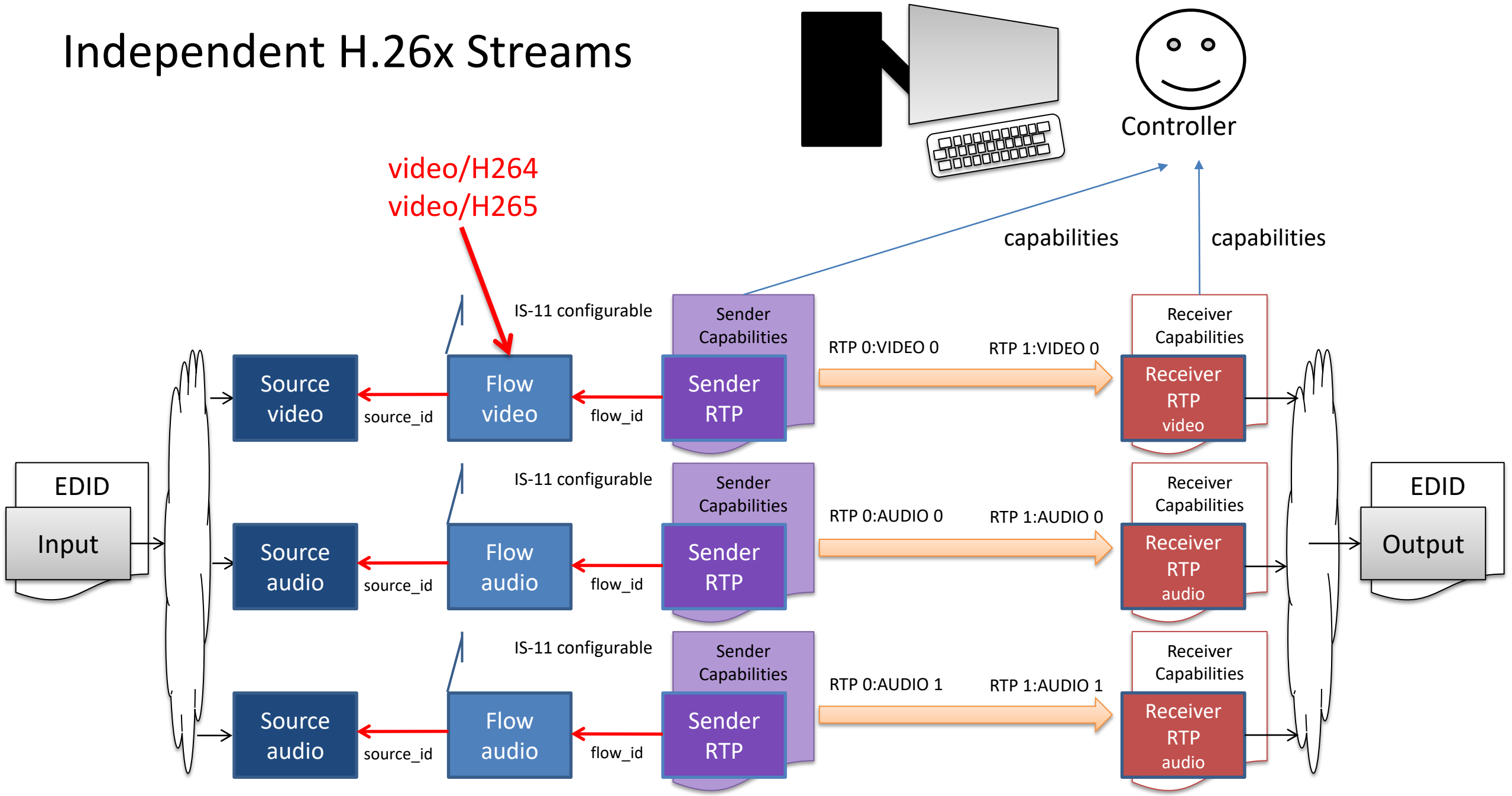
| H.265 Profiles (partial list) | |
|---|---|
| "Main" | "Main-444" |
| "Main10", "Main10-422" | "Main10-444" |
| "Main12", "Main12-422" | "Main12-444" |
| "MainIntra" | "MainIntra-444" |
| "Main10Intra", "Main10Intra-422" | "Main10Intra-444" |
| "Main12Intra", "Main12Intra-422" | "Main12Intra-444", "Main16Intra-444" |
| "Monochrome", "Monochrome10", "Monochrome12", "Monochrome16" | "HighThroughput-444", "HighThroughput10-444", "HighThroughput14-444", "HighThroughput16Intra-444" |

- H.265 offer many profiles for various compression use-cases:
  - intra and inter coding algorithms
  - 4:2:0, 4:2:2 and 4:4:4 color sampling
  - 8, 10 or 12 bit per component
  - multi-planes and single-plane coding algorithms

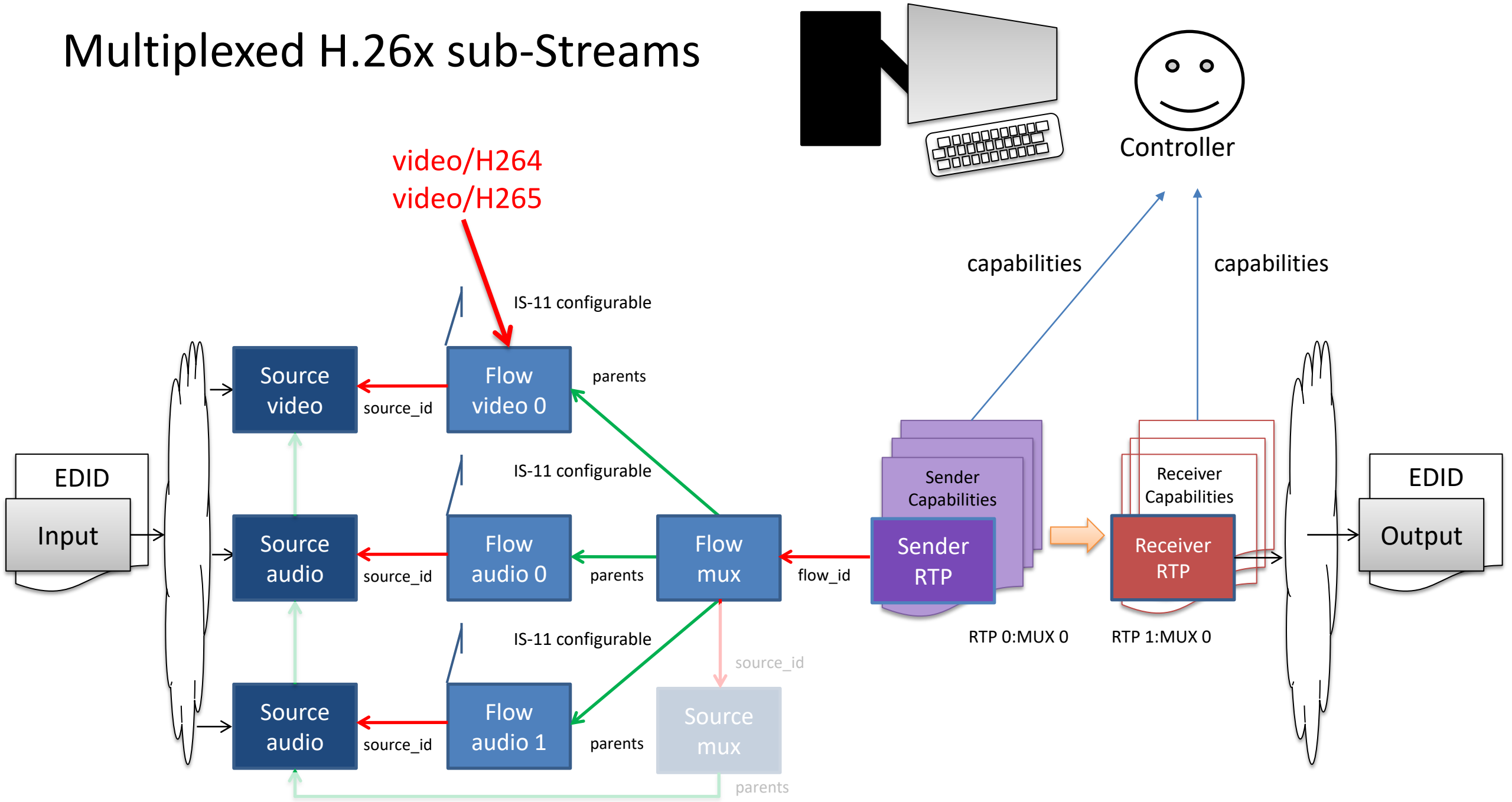
# Applying IS-11 Active Constraints

- Applying constraints to **profile** and **level**
  - Aspects of a codec profile relate to other independent parameters
    - Ex. H.265 "Main" profile does not allow 4:2:2 and 4:4:4 color sampling
  - Aspects of a codec level relate to other independent parameters
    - Ex. H.265 "Main-1" level has a maximum macroblocks rate (w, h, fps)
  - A User is responsible for applying “valid” constraints
    - Strategy:
      - Apply the minimum set of constraints and allow the device some freedom.

# Independent H.26x Streams



# Multiplexed H.26x sub-Streams



- This concludes our overview of NMOS with H.264 and H.265, a key feature of Matrox NMOS Advanced Streaming Architecture.

- If you have any questions, feel free to reach out at abouchar@matrox.com.

- Thank you for attending.