CE Linux 2007 – GStreamer Tutorial

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Introduction - GStreamer

- Been around a long time
  - 0.0.1 – 10th June 1999
  - 0.3.0 – 12th Dec 2001
  - 0.4.0 – 5th July 2002
  - 0.6.0 – 1st Feb 2003
  - 0.8.0 – 16th March 2004
  - 0.10.0 - 5th Dec 2005
- The problems GStreamer was started to address
- “What you have is what you get” media players

GStreamer is extensible

Functionality provided by plugins

Binary codec support was always a goal

Introduction - GStreamer

Every project with its own MP3 decoder

GStreamer is a library

- *Applications just link to it to get functionality*
- *LGPL license allows proprietary apps*
- *Used to be a bigger problem than now (xine vs mplayer, vlc)*

Inconsistent APIs - ALSA, OSS, X11 etc

Has never been 'just playback'

GStreamer reaps the benefits of abstraction

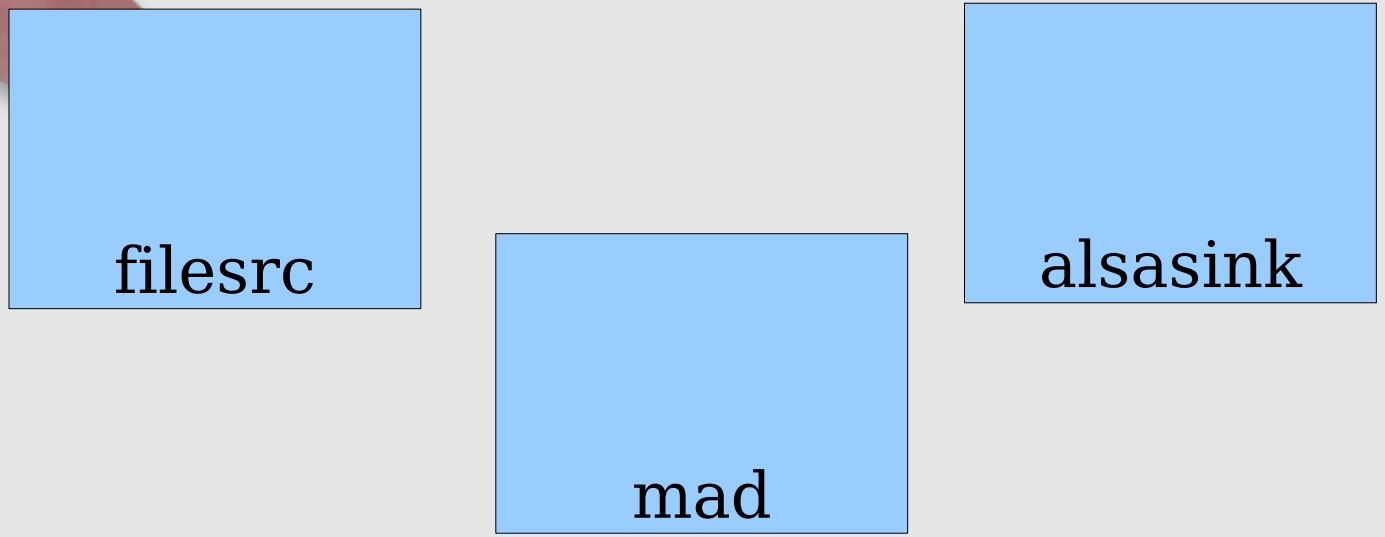
- *Elements + pads == arbitrary flow graph*
- *Decoding, encoding, delivery, slicing and dicing*

Introduction - GStreamer

- The parts:
  - Elements
  - Bins
  - Pads
  - Caps

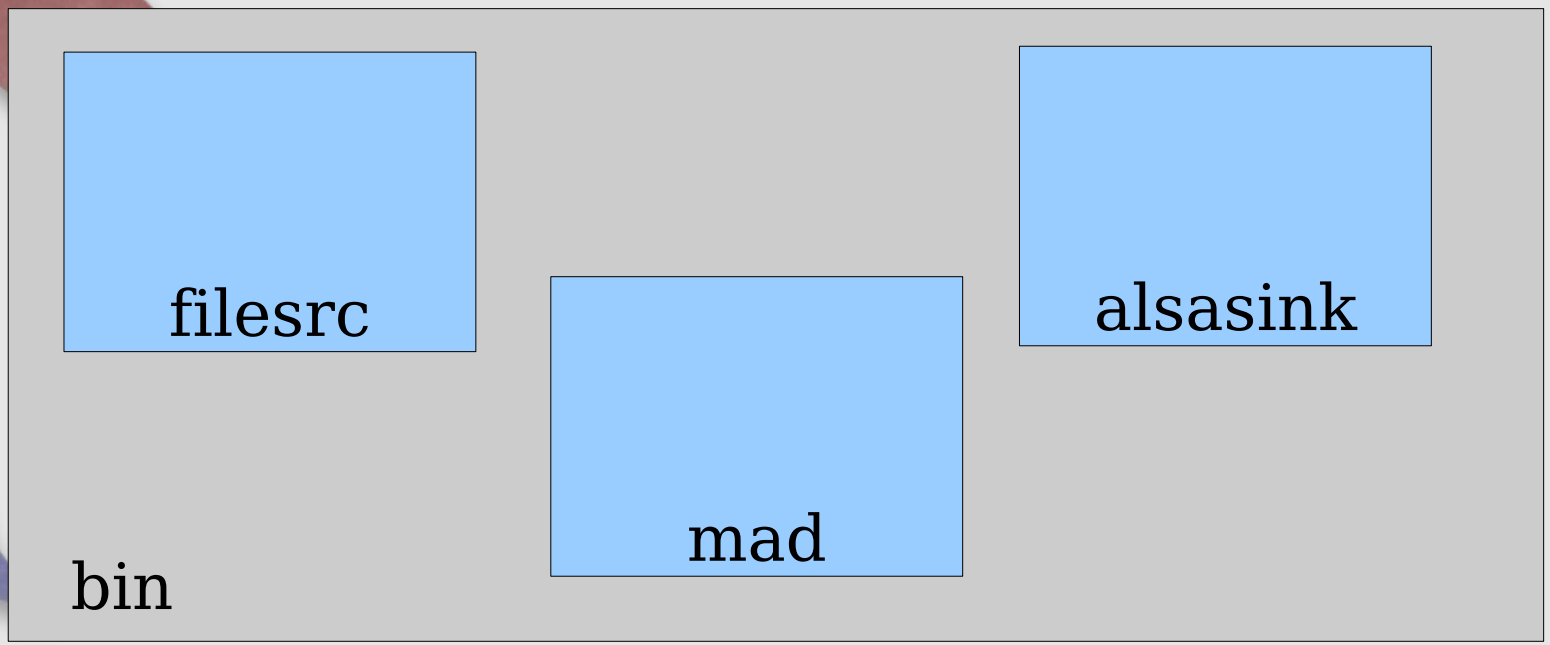
Basic parts of GStreamer

- Elements
  - The basic units of functionality



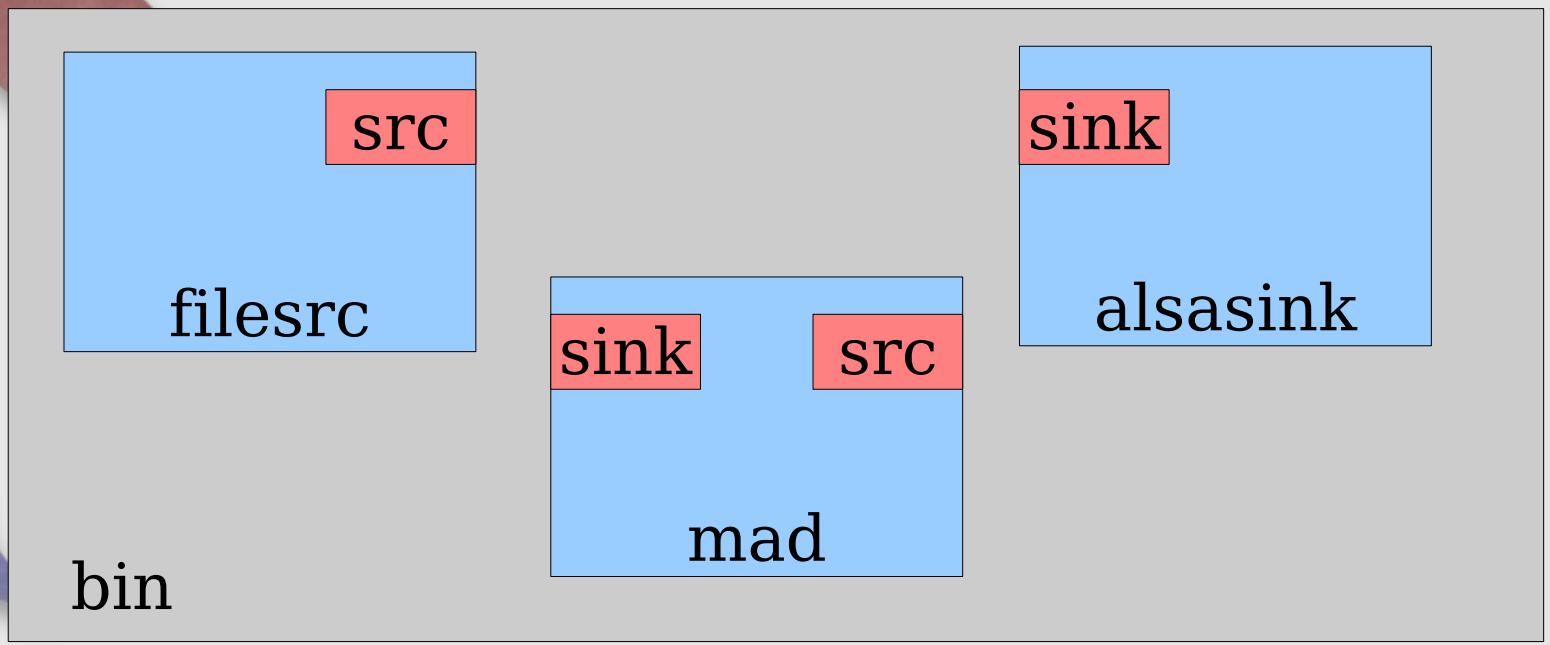
Basic parts of GStreamer

- Bins
  - Elements that contain other elements
  - Allow multiple elements to be treated as one entity
  - The top-level bin is a 'pipeline'



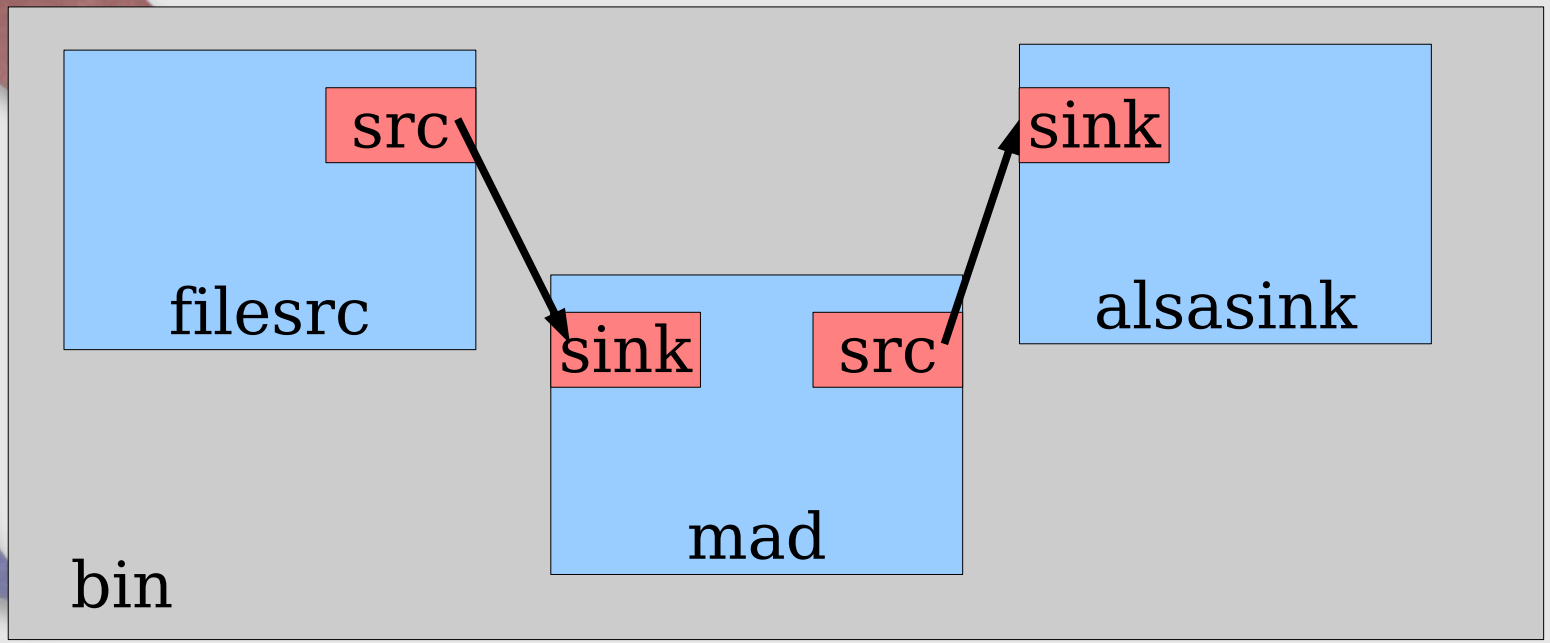
Basic parts of GStreamer

- Pads
  - Connection points between elements
  - Name originally comes from soldering and electronics



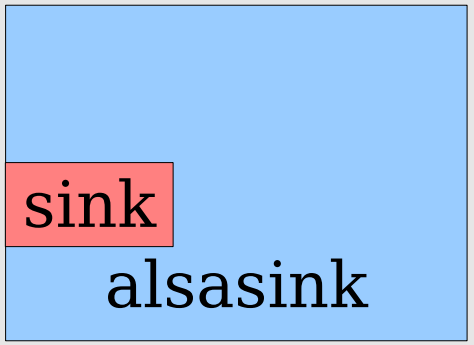
Basic parts of GStreamer

- **Source** pads produce data
- **Sink** pads consume data

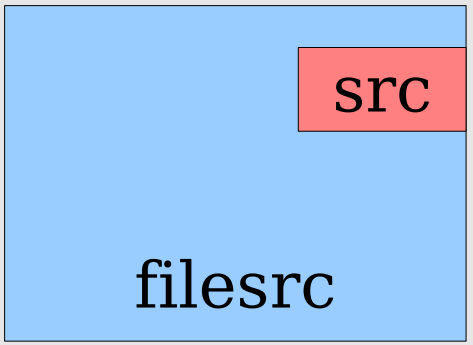


More terminology

- A sink element has only sink pads



- Likewise for source (src) elements



The registry

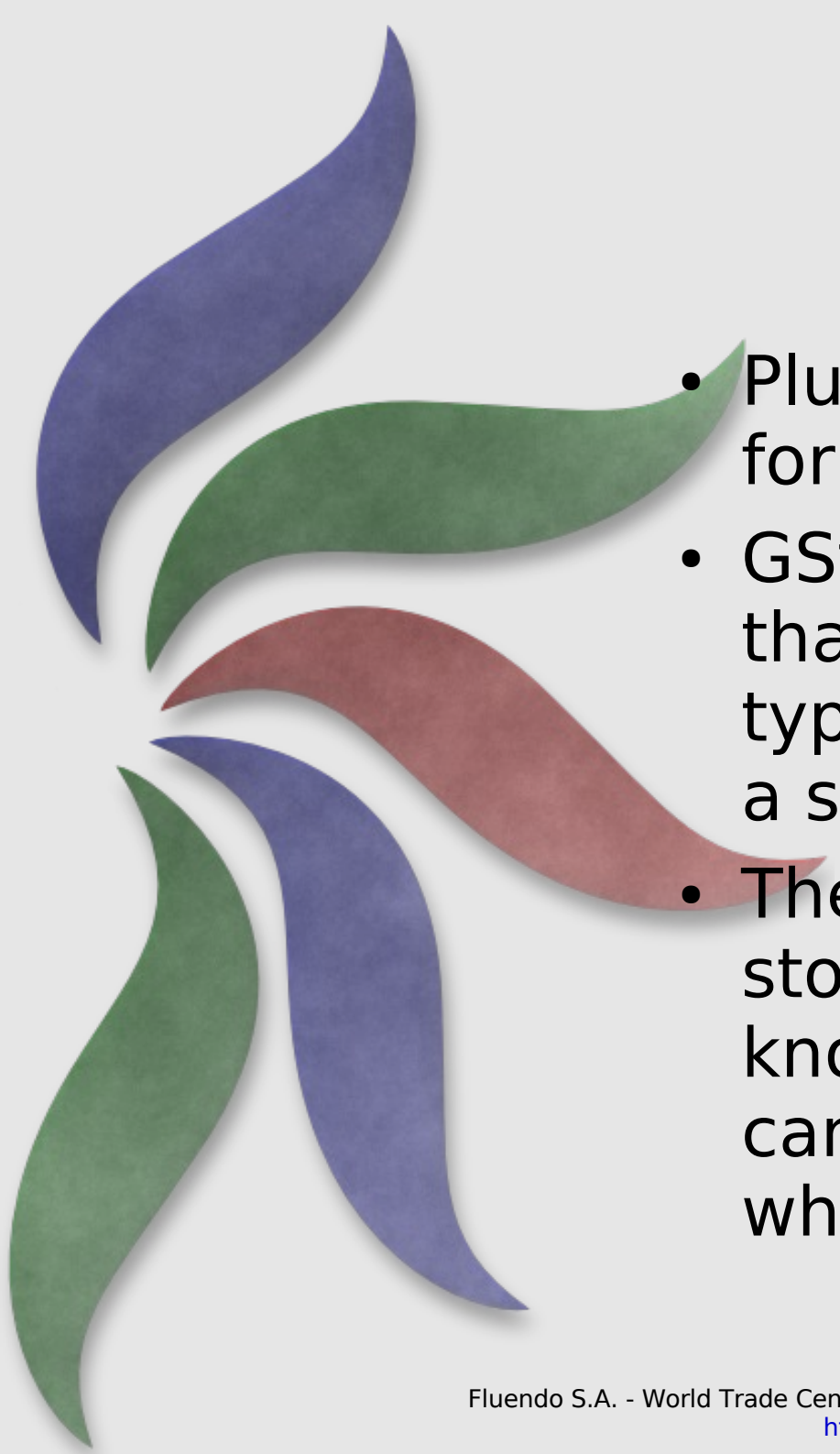
- GStreamer keeps a list of what plugins are available, and what features they provide
- Plugins are loaded as-needed
- (See gst-inspect)
- Automatically regenerated when new plugins are installed.

Data types: “Caps”

- Media type + set of properties
- Text representation:

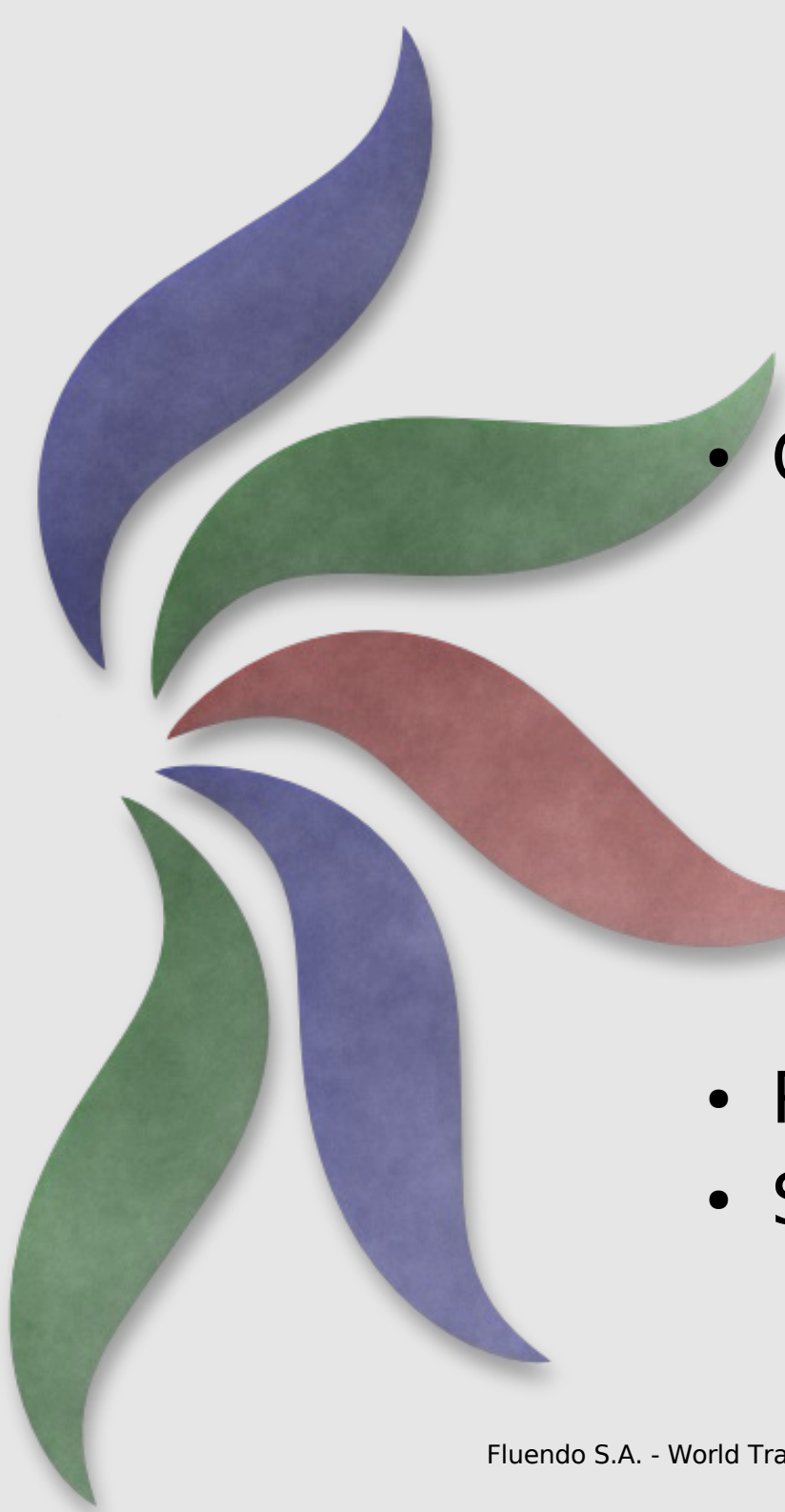
audio/x-raw-int,
rate=(int)44100,
channels=(int)2,
endianness=(int)1234,
width=(int)16, depth=(int)16

video/x-raw-yuv,
format=(fourcc)I420,
width=(int)[1, 2147483647],
height=(int)[1, 2147483647],
framerate=(fraction)[0/1,
2147483647/1]



Autoplugging

- Plugins can provide typefinders for specific formats.
- GStreamer provides an element that uses the provided typefinders to detect the type of a stream.
- The possible caps of pads are stored in the registry. Once we know the type of a stream, we can use the registry to find which element to use.



Data passing: Buffers

- Contents:
  - A pointer to the actual data being passed
  - A reference to a caps structure
  - Timestamp, offset, some other metadata
- Reference-counted
- Subbuffers

Events

- Messages passed in both directions up and down the pipeline
- Can be in-band or out-of-band
- Examples:
  - Seeking
  - Flush
  - Segments

Data passing: Events

- Used to find out about the pipeline.
- Examples:
  - Position
  - Duration
  - Seeking

Controlling data flow

- gst_element_set_state (element, state)
- NULL
  - All resources deallocated, devices released
- READY
  - Devices opened
- PAUSED
  - Buffers begin to flow, blocked in the sinks
- PLAYING
  - All systems flow

Threads

- Tell an element to go to PLAYING, and something starts happening behind the scenes...
- Data flow happens in separate threads
  - States change asynchronously
- GStreamer is thread-safe when using API functions.

The bus

- Receives messages from elements
  - End-Of-Stream, error, warning, tags (title, track, etc.), state changes...
- Marshals the messages to the main thread
- Apps can, for the most part, ignore the existence of threads

Memory management

- Most objects you might deal with are refcounted.
- With few exceptions, most functions that give you an object give you a new reference
- Special case for objects that can be parented: floating references

The Debug System

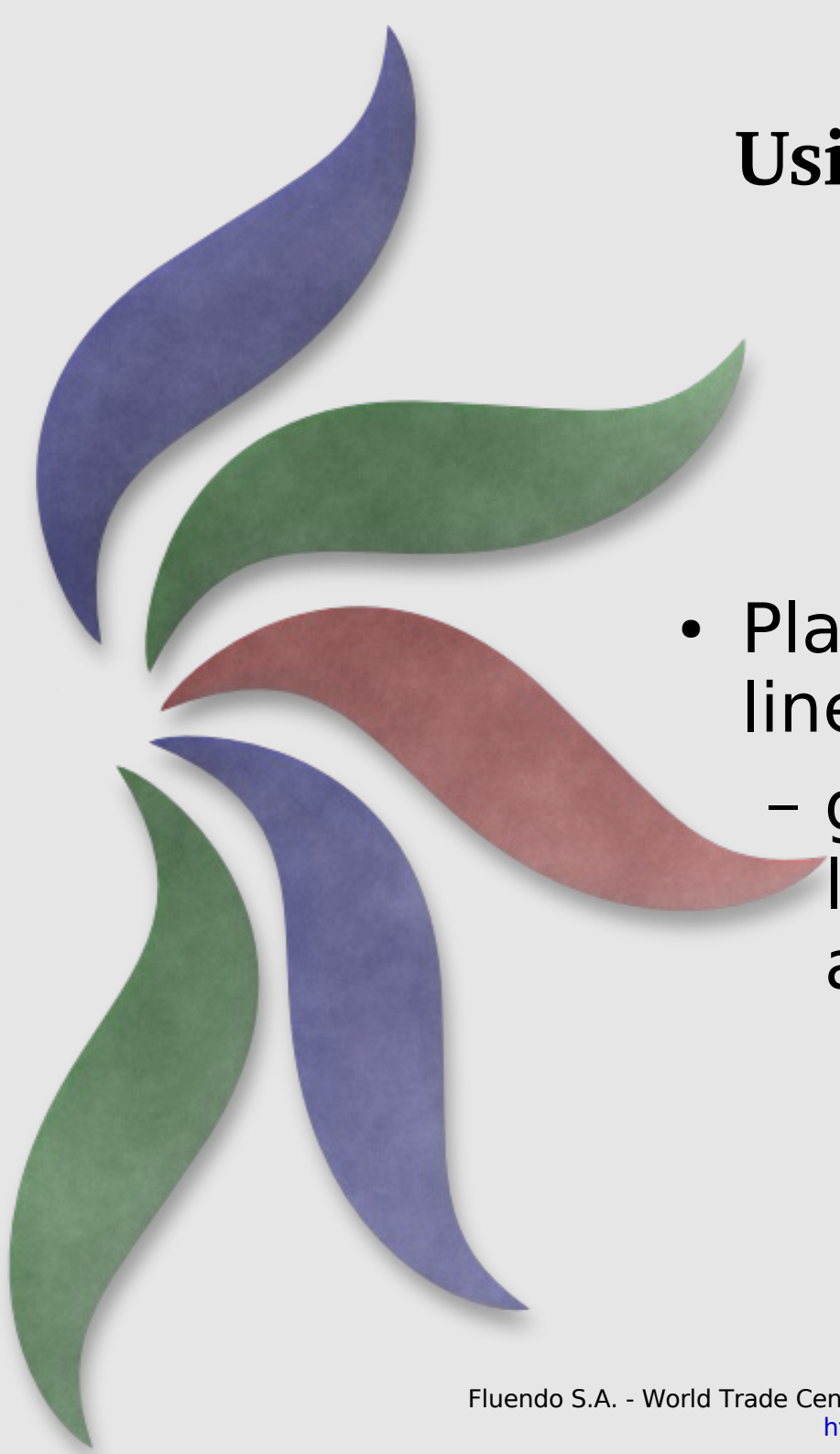
- Elements are instrumented with debug output using macros.
- Debug statements are directed to a specific category, and debug level.
- The output is only produced if the category and level are enabled.
- Preferably elements also supply the GstObject outputting the message – makes the output more useful.

The Debug System cont.

- Plugins can register their own debug categories.
- See the list of available categories:
  - gst-inspect –gst-debug-help
- 5 levels available: ERROR, WARN, INFO, DEBUG and LOG
- To turn all categories on set the GST_DEBUG env var to the level:
  - GST_DEBUG=5 gst-launch ....

The Debug System cont.

- Turn on specific debug categories:
  - GST_DEBUG=filesrc:5,GST_PADS:3 gst-launch ...
- Can use wildcards:
  - GST_DEBUG=*src:5 gst-launch...
- Works with all apps of course, (not just gst-launch)
- The overhead is fairly low for disabled categories, but the whole thing can be compiled out.

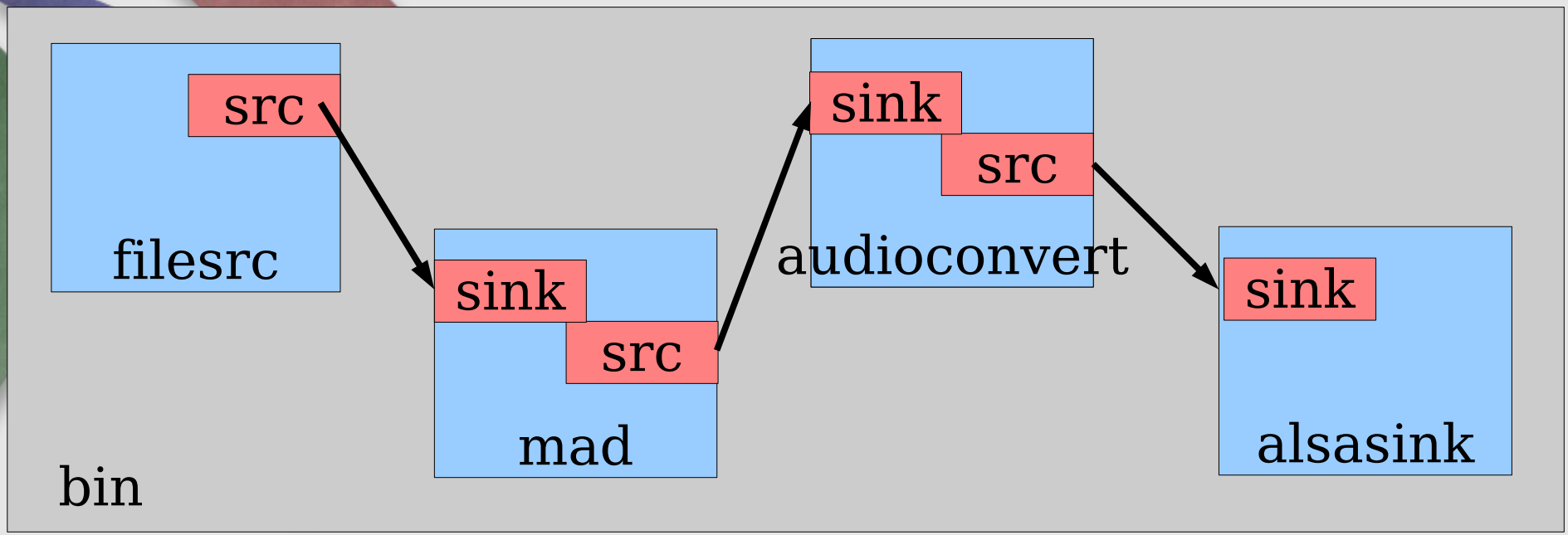


Using GStreamer – Example 1

- Play an mp3 from the command line
  - gst-launch filesrc location=file.mp3 ! mad ! audioconvert ! alsasink

Using GStreamer – Example 2

- Can do the same pipeline in code using gst_parse_launch

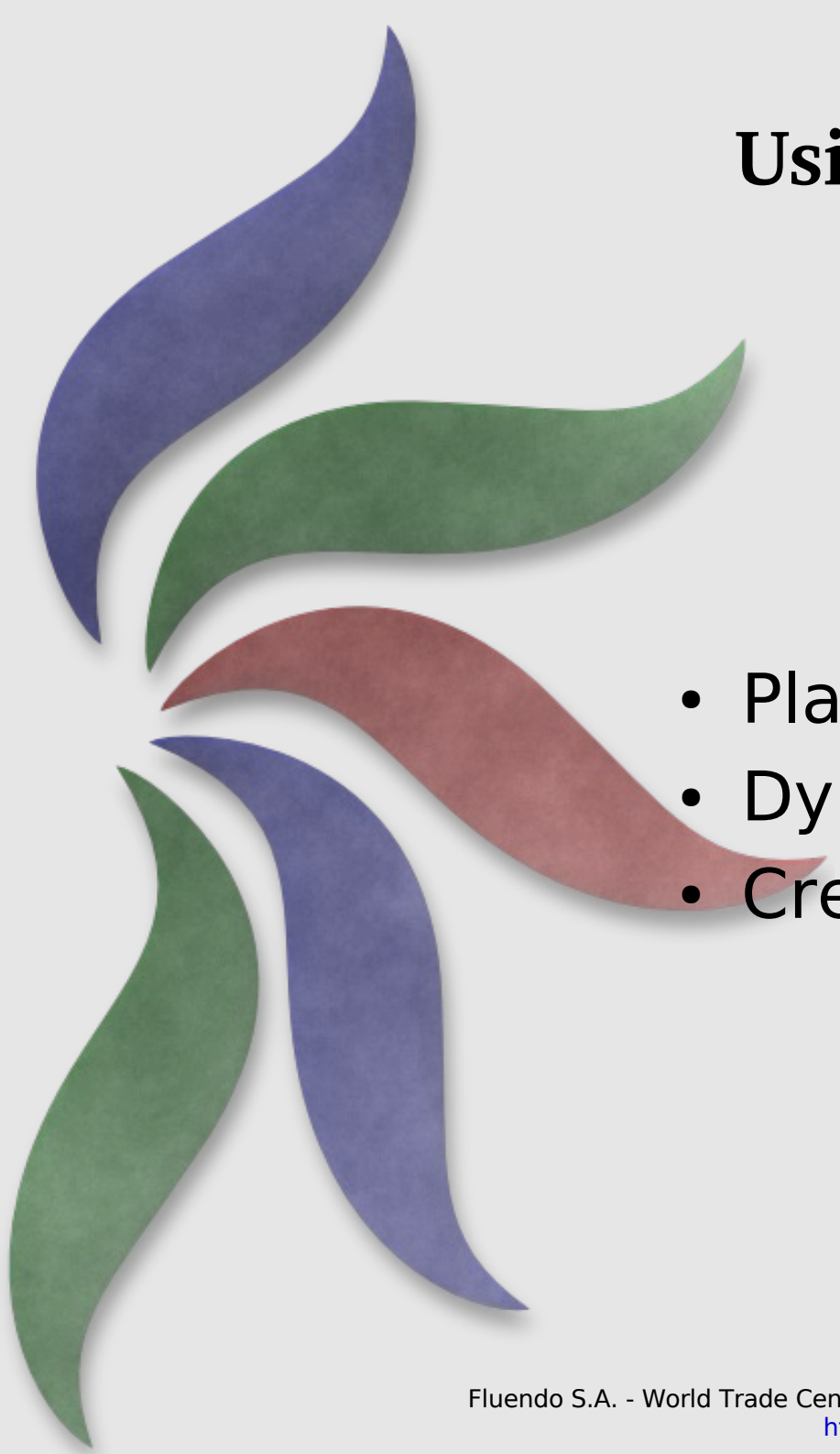


Using GStreamer – Example 3

- Build the elements manually and connect them

Using GStreamer – Example 4

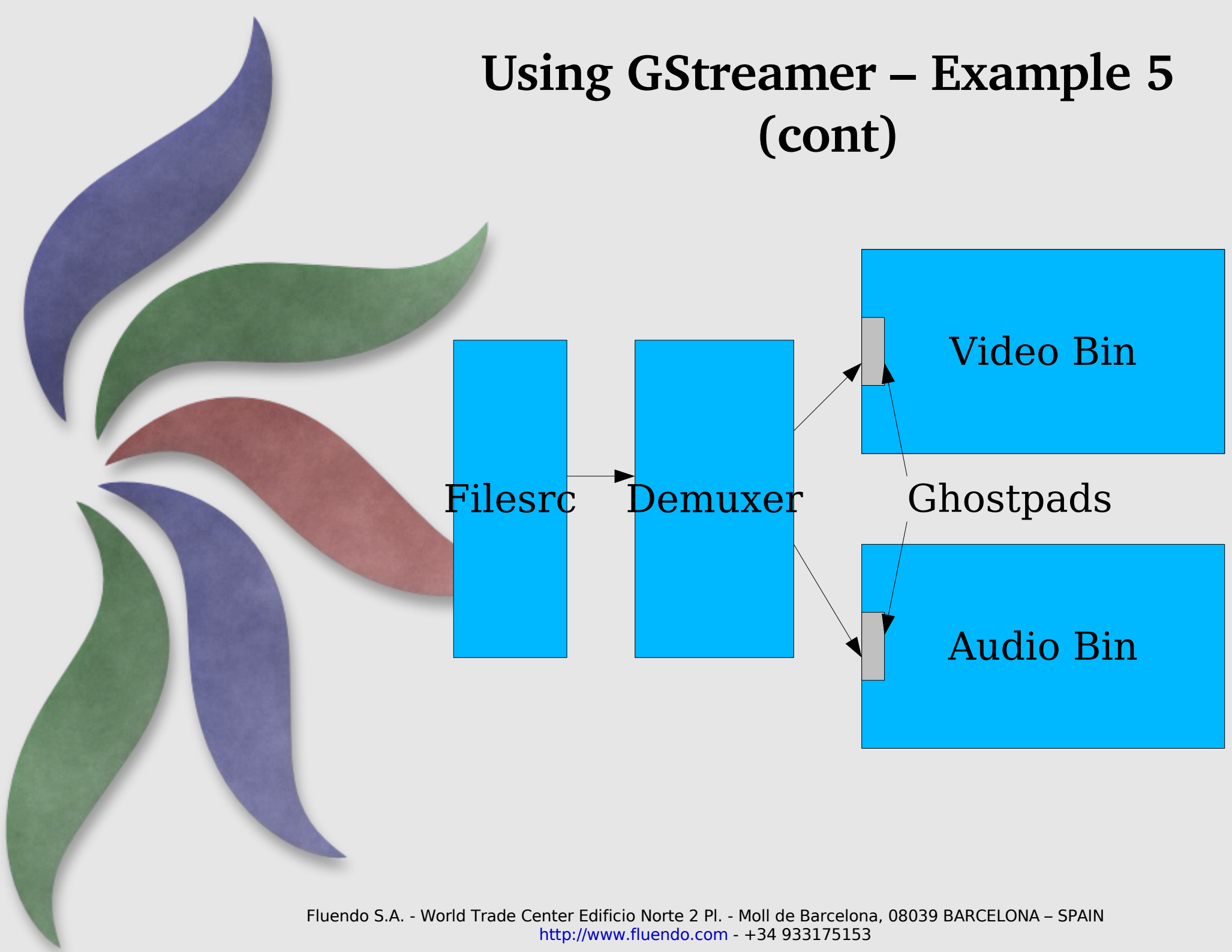
- Only plays for 5 seconds – need to listen on the bus for messages



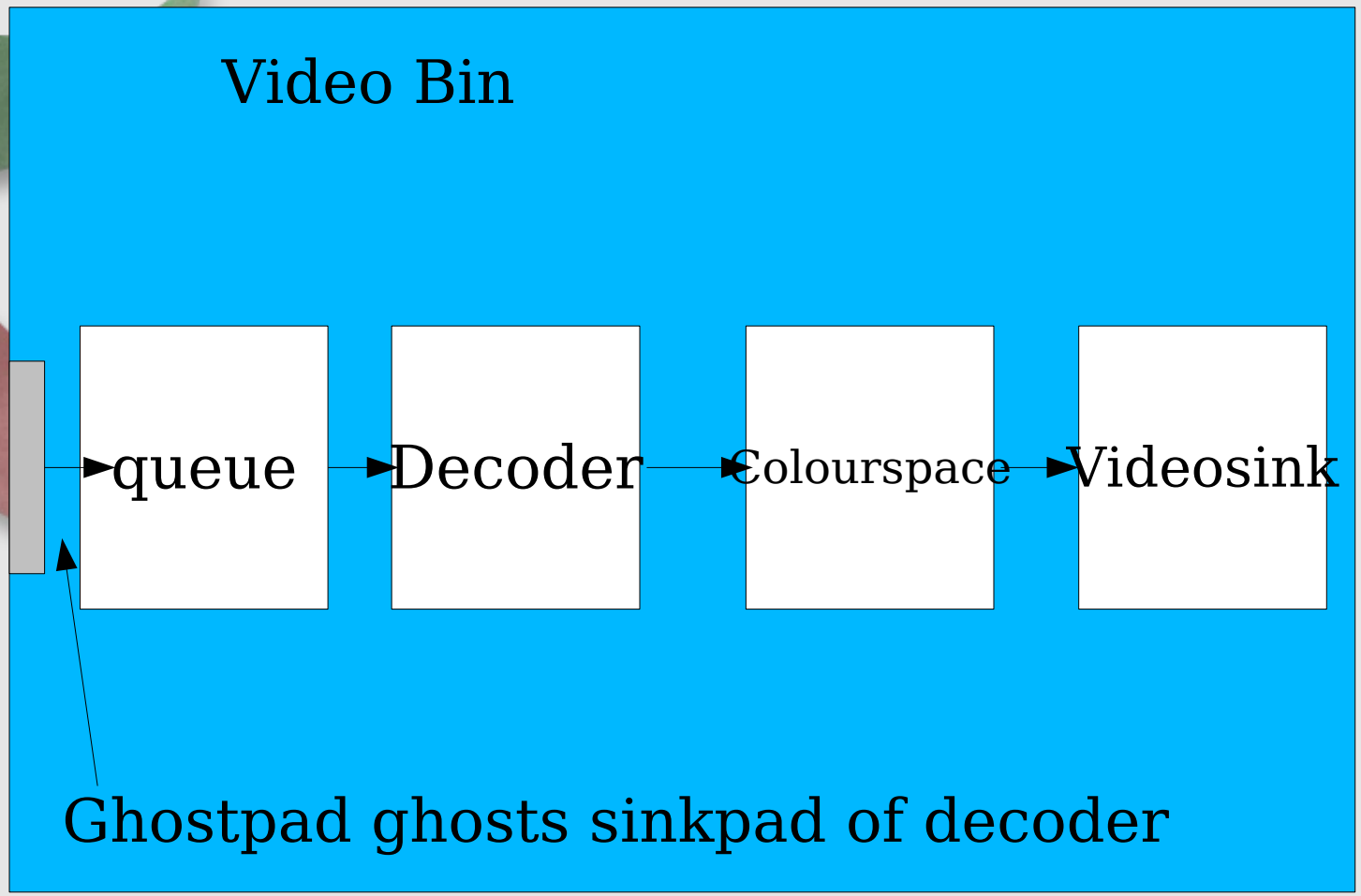
Using GStreamer – Example 5

- Playing Audio + Video together
- Dynamic pads
- Creating elements on the fly

Using GStreamer – Example 5 (cont)



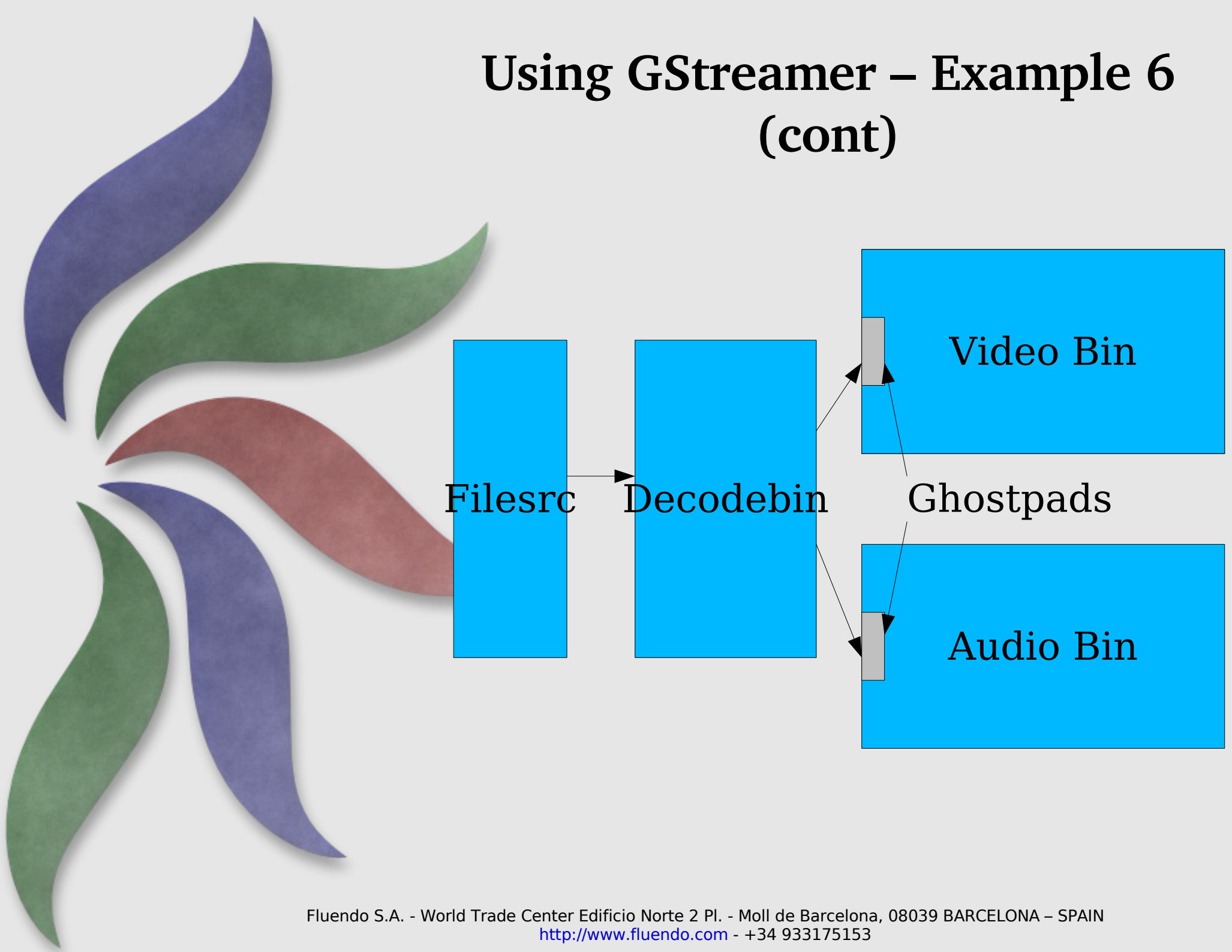
Using GStreamer – Example 5 (cont)



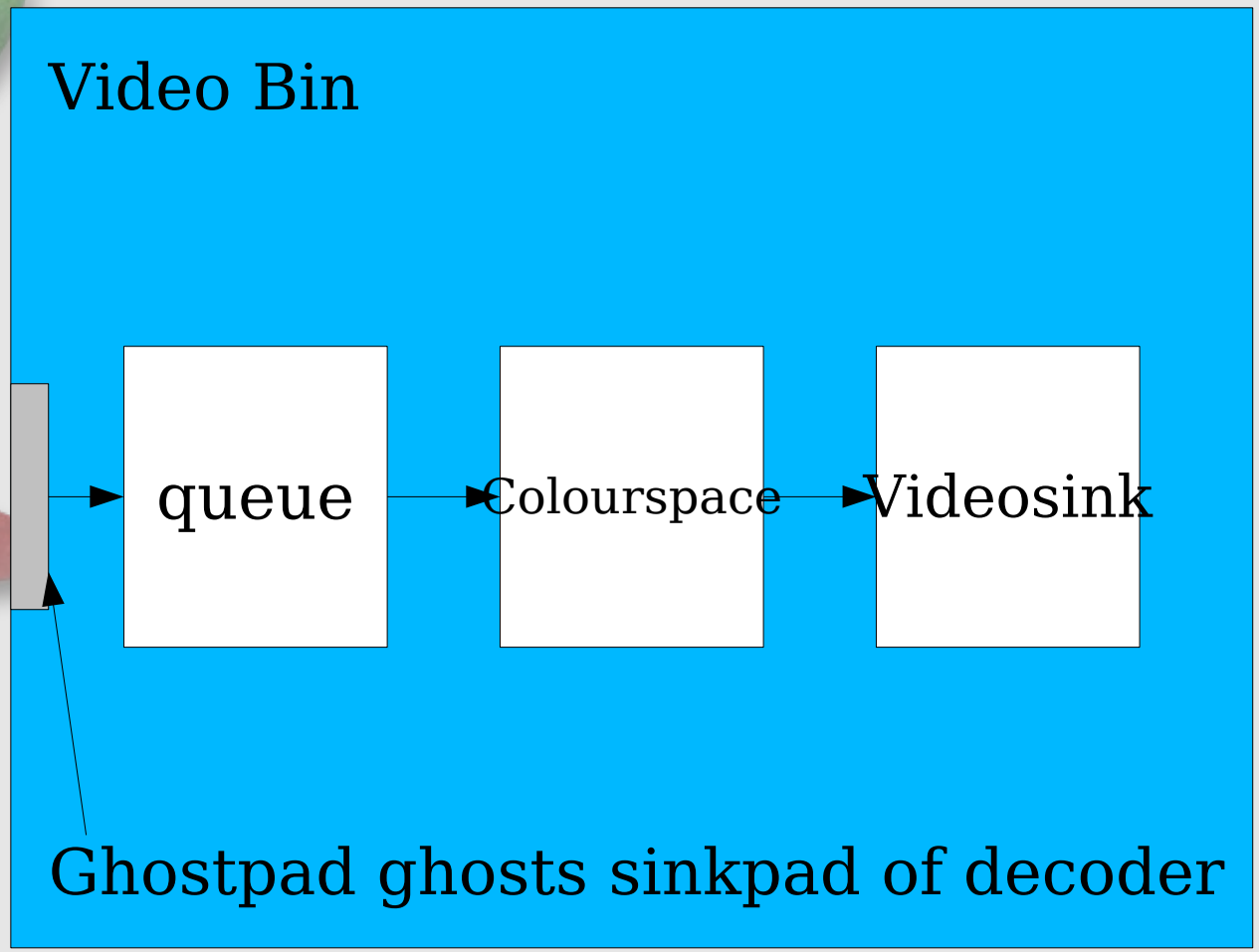
Using GStreamer – Example 6

- Using Decodebin to save effort
- decodebin will give you a raw stream if it can, and a decent error if it can't.

Using GStreamer – Example 6 (cont)



Using GStreamer – Example 6 (cont)

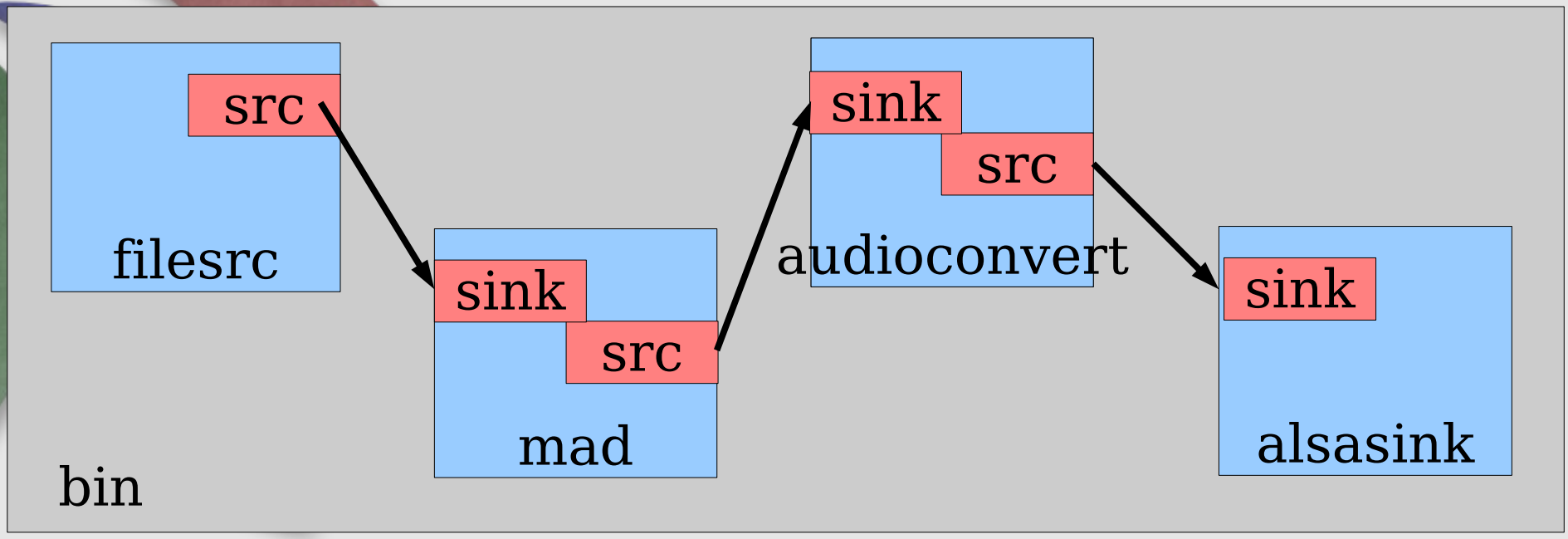


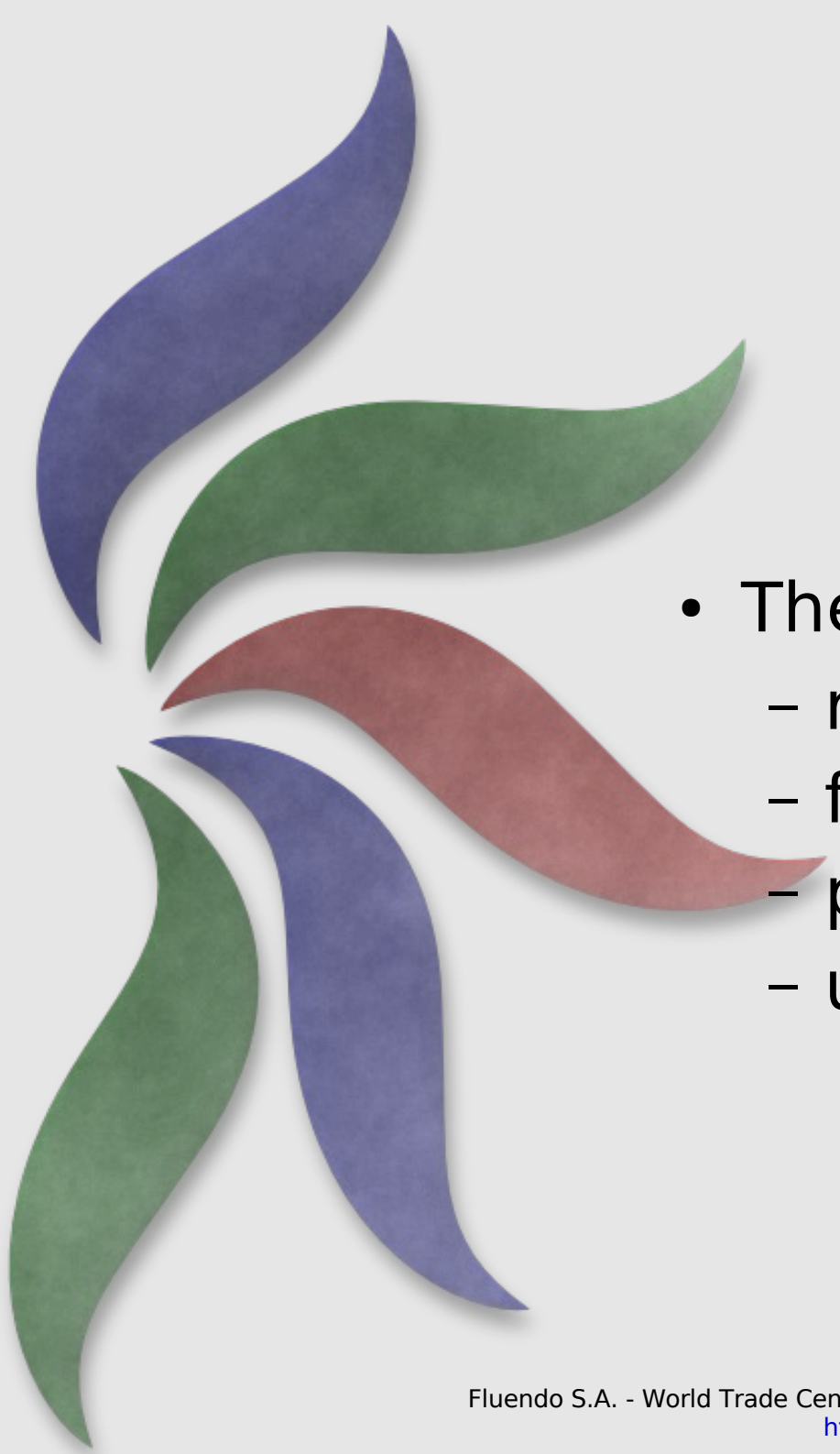
Using GStreamer

- In many cases, to just do playback, can just use playbin

Dataflow

- Step 1: Getting to « READY »
- Step 2: Starting data flowing
  - Pre-roll
  - Segments
  - Buffers





Dataflow - Segments

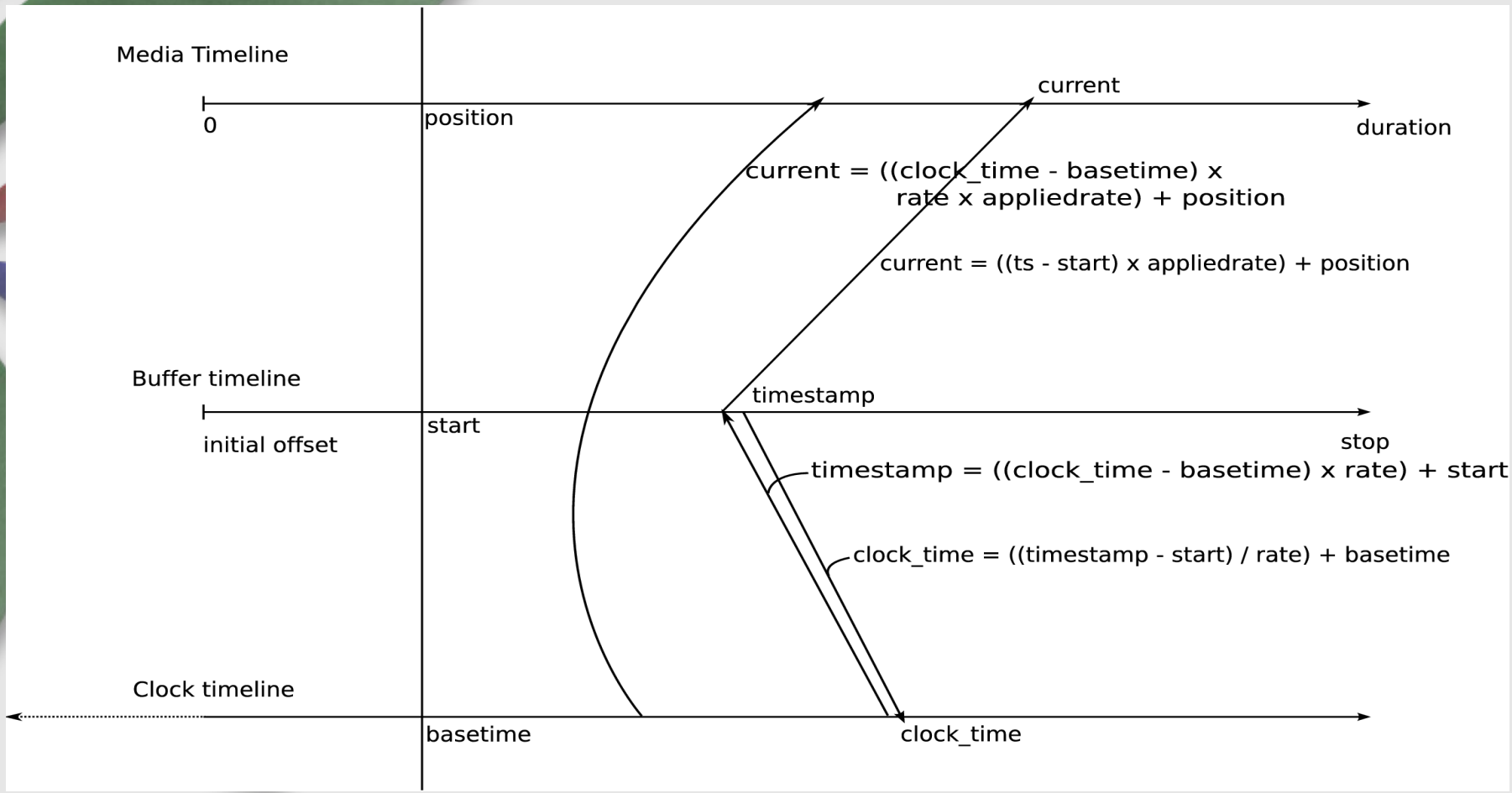
- The New-Segment event
  - rate, applied_rate
  - format, start, stop
  - position
  - update flag

Dataflow

- Step 3: Playing
  - Clocks
- What GStreamer uses clocks for
  - Playback synchronisation
  - Capture timestamping
- master and slave clocks
- Clock selection in a pipeline
  - Prefer clocks closer to sources
  - Overriding clock selection
- When is a clock advancing
  - PLAYING vs. PAUSED, basetime

Dataflow - Synchronisation

- Leads to:



Different types of GStreamer elements

- Decoders
- Sinks
- Converters
- Demuxers
- Sources
- Encoders
- Muxers
- Filters

Decoders

- Usually the simplest – the output format is dictated by the input and output.
- Receive some buffers, decode some data if possible
- Should always use buffer-alloc
- Flushing events
- Querying
- Talk about New-Segment

Sinks

- Provide buffers upstream
- Usually derive from BaseSink to get the clock synchronisation, QoS and event handling for free
- Format (caps) negotiation can be complex

Converters

- Often basetransform based so they get event handling, pull-mode, QoS and reverse negotiation for free

Demuxers

- Usually the most complicated elements, as they're often the ones driving the pipeline
- Multiple source pads
- Need queues after to decouple
- Seek handling is the most complex
- Format negotiation isn't usually a problem
- Need to remove pads on format changes/new streams/PAUSED->READY transitions

Sources

- Generate data
- Format negotiation can be complex, but not usually
- Using BaseSrc makes sense:
  - Event handling for free
  - Pull mode operation

Encoders, Muxers, Filters

- Content creation half of the equation
- Encoders mirror decoders, generally pretty simple
- Muxers are more complicated because they need to deal with re-ordering multiple input streams
- Filters based on BaseTransform, like Convertors