Every Solution is Wrong:

Normalizing Ambiguous, Broken, and Pants-on-Head Crazy Media

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NTTW3

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London, UK

New phone, who dis?

- Senior Video Engineer @ Vimeo
    - Some things I’ve worked on:
        - Transcoding pipeline (pre- and post-chunking)
        - Edge stateless segmenting (DASH, CMAF, HLS, etc.)
        - On-the-fly image recompression
        - Captions stack
- Open source developer (FFmpeg, FFMS2, etc.)
- VideoLAN non-profit board member
- Professional Twitter Sh*tposter

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  - The users that don’t will send you massively varying media
- We don’t have the luxury of demanding they upload correct/perfect media
- We need to be able to ingest this vast array of media as best possible
  - Must be consistent
  - Result must be widely playable while best maintaining the user’s intents
  - Anger the least amount of users
- Provide users with a easy to digest recommendations based our analysis

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- We need to do analysis and run heuristics before transcoding to make informed choices:
  - Does this file have enough well distributed RAPs to efficiently chunk? Can we even seek?
  - Do we need to convert colorspace, and if so, to what? What about HDR?
  - Do we need to scale (SAR/DAR), and to what? Cropping?
  - Do we need to un-screw timestamps, and how? Is there concept of a frame or field rate?
  - Is the file interlaced? Telecined? Is it tagged as such?
  - Do we need to resample audio? Downmix? How?
  - How should we sync audio? Do we need to pad? Silence-fill?
  - Other misc stuff like Apple “Slow-mo”, spherical video, MVC, etc.
  - More, more, more…

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- Video:
  - Derive a per-stream score based on various factors
    - Is it marked as a thumbnail stream? Is it marked as default / on?
      - Some media such as slideshows **only** have a timed thumbnail stream
    - Is it (M)JPEG?
    - Total duration?
    - Bitrate? (taking codec into account!)

Pick Your Poison

- Audio:
  - If downmixing, prefer the official downmixed version, if present, over downmixing ourselves
  - Prefer streams with earlier start times
  - If they all start at the same time, prefer longer durations
  - If everything else fails, go by lowest index

Indexing and you

- Every file / stream is indexed, info collected includes frame types, timestamps, etc.
  - The file is not decoded during this phase, only demuxed in memory
  - Can pass around and store info needed for analysis
  - Seek easily for containers that may not have indexes

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  - Seek easily for containers that may not have indexes
- Much faster than a full decode, especially for things like JPEG2000
- Essentially building a packet-to-frame mapping
  - Harder than it sounds due to things like:
    - alt-refs – VP8 requires packet inspection, VP9 **may**, AV1 doesn't
    - NVOPs – Need to be skipped.
    - PAFF – Need to handle field packets
    - Virtual timelines (edit lists, ordered chapters)

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    - We don’t want to try seeking in files with one or no keyframes (no block-level ref analysis)
    - Something like a weighted quantile in the time domain based on keyframe distances (90th percentile)
        - How likely are we to end up with a RAP within N frames of a seek?
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- Preferable to chunk based on shot (or rather, cost effective) boundaries, if available
  - Note that source RAP placement is not necessarily indicative of a Good™ chunk boundary

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- Some poor encoders pad odd resolution 4:2:2 or 4:2:0 files with grey or green, but don’t set crop params
  - Detect and remove this as an edge case
- Some decoders will output impossible things like non-mod 4 4:1:0
  - Need to special case (different decoders do different things) and pad/crop as appropriate

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- Try to detect interlaced or telecined content based on frame content
  - Try to detect temporally distinct fields by how different even/odd lines are
    - Running sum spatially for field detection
    - Running sums temporally for previous, current, and future for added field order detection
  - Pattern detection for telecined content
    - e.g. CCNNC (reset at RAPs) for 3:2 pulldown

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- Try and detect “fake” 50i and handle appropriately

Colorspaces

- More cringe warnings!
- Almost every non-HDR device requires BT.709 or SMPTE170M matrix/transfer/primaries
  - Try and convert based off tags if possible, try and fudge it otherwise (devices **need** color info)
  - Conversions need to be gamma-correct (swscale is terrible, use zimg[1] instead)
  - Last resort guessing based on various identifying characteristics (PAL/NTSC matters!)

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- 10-bit input (not necessarily HDR!) is dithered accordingly with a random dither algorithm
- HDR input is ingested no matter what it is, although we only output HDR10-style media
  - Would have liked to use HLG, but Apple and Dolby exist
  - Need to make SDR versions, of course
    - Nominal peak luminance detection (zimg plays nice here)
    - In-house tonemapping like libplacebo's Möbius transform-based algorithm[2]

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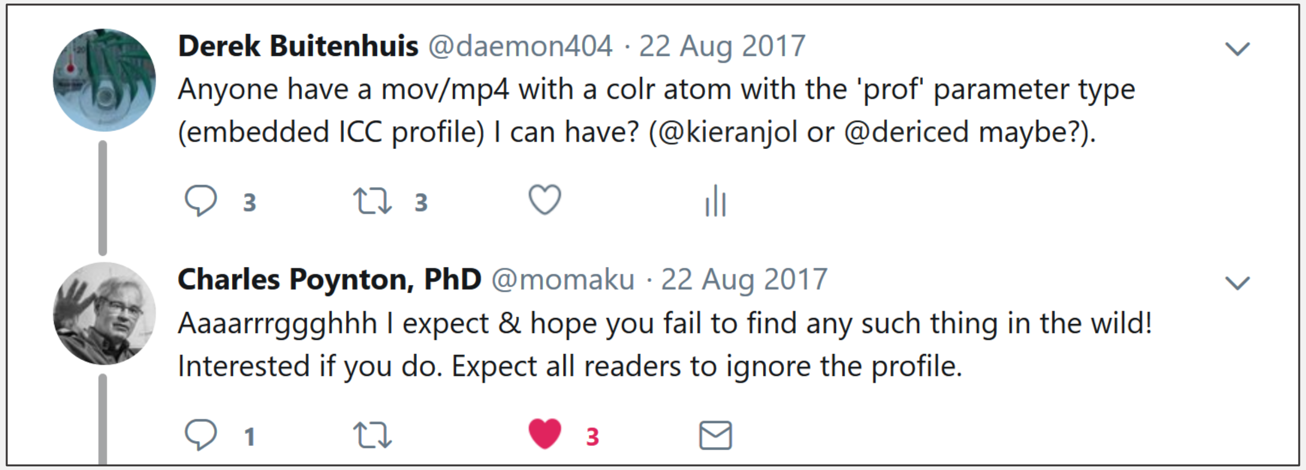
- ICC profiles may be shipped with some codecs or containers
  - Extracted from e.g. MJPEG frames
  - ISOBMFF colr boxes may contain ICC profiles… in theory



Derek Buitenhuis @daemon404 · 22 Aug 2017
Anyone have a mov/mp4 with a colr atom with the 'prof' parameter type (embedded ICC profile) I can have? (@kieranjol or @dericed maybe?).
3 3

Charles Poynton, PhD @momaku · 22 Aug 2017
Aaaarrrggghhh I expect & hope you fail to find any such thing in the wild! Interested if you do. Expect all readers to ignore the profile.
1 3

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- There are so many ways that timestamps can be screwed up. Too many to enumerate.
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- We always deliver CFR content to clients/devices (come at me, bro), so need to choose a “good” rate
  - Quicktime bug-friendly, precision reduced to fit in e.g. H.264 or container fields
- Our indexing from earlier provides us with all the timestamp info for easy analysis
  - Analysis on DTS/PTS and frame durations (all done in arbitrary precision rational arithmetic)
    - Take into account allowed positive and negative timesamp discontinuities
    - Smooth extreme outliers (usually corruption) based on some metrics, e.g. stddev
    - If the file is an amalgamation of multiple CFR segments, choose the “best” rate
    - If it’s “true” VFR, try and fudge a “good” middle ground rate

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- Make sure to take into account all things that can modify rates (e.g. mdia rate, trak rate, stts, edts)

It just sounds, like, warmer, man…

- Downmix when needed for various devices
  - If the format inherently has info for this (e.g. AC3), use it
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  - Some formats don’t have a separate time base for audio/video
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- Resample when needed to a known-good set of sampling rates

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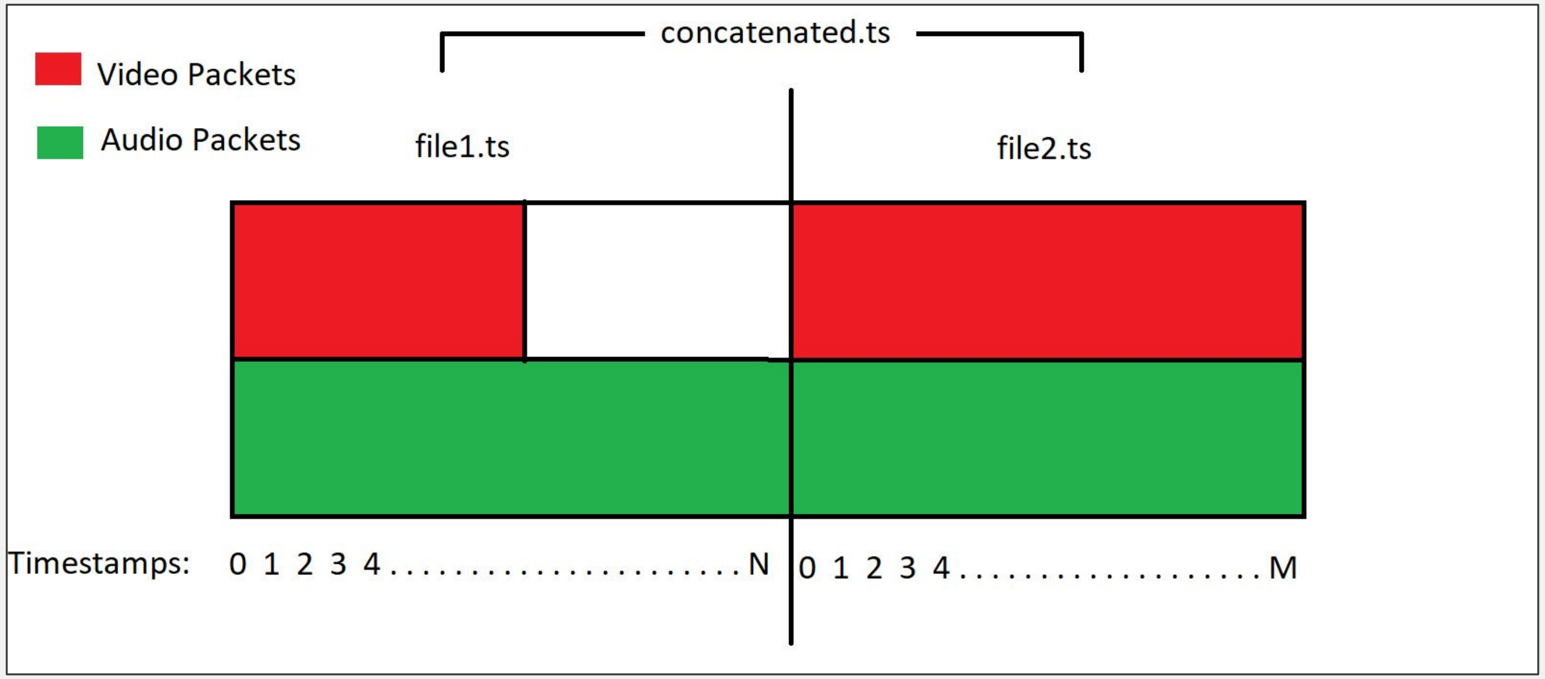
- Cannot look at audio in isolation
  - Need the video to interpret audio timestamps correctly


concatenated.ts
🟥 Video Packets
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file1.ts
file2.ts
Timestamps:
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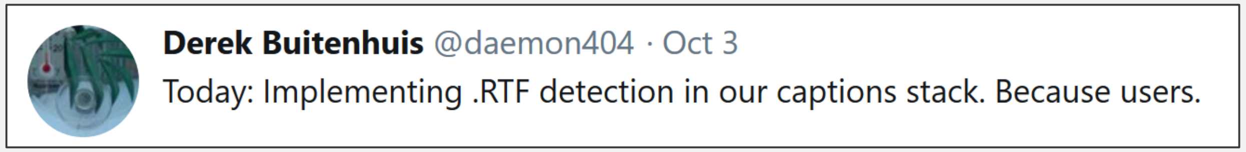
- Detect common mistakes like pasting captions into Word and upload…


Derek Buitenhuis @daemon404 · Oct 3
Today: Implementing .RTF detection in our captions stack. Because users.

But wait, there’s more!

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  - Spherical video, equirectangular video, 3D, ambisonics, etc.
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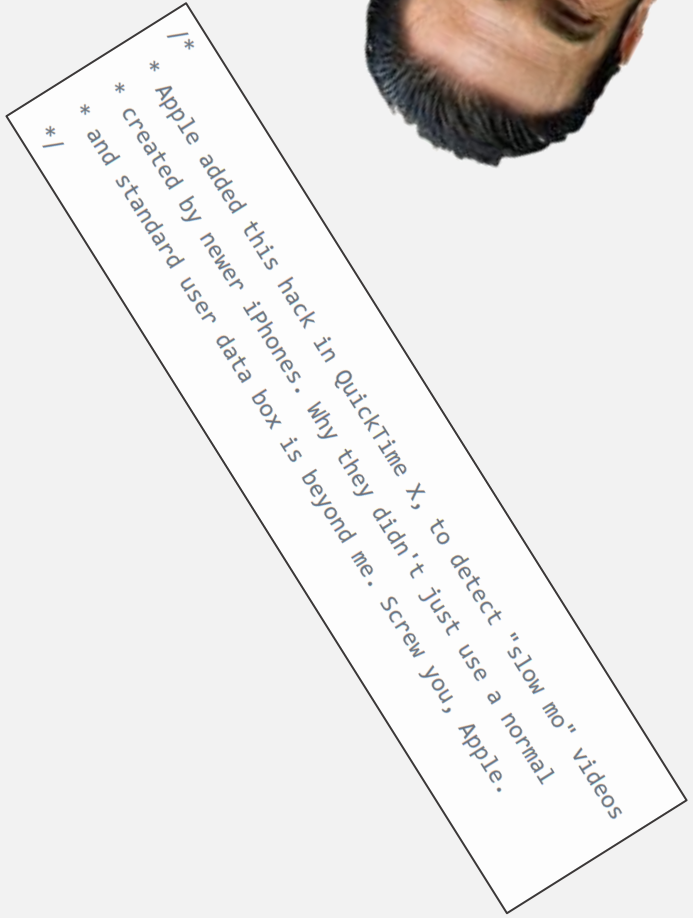

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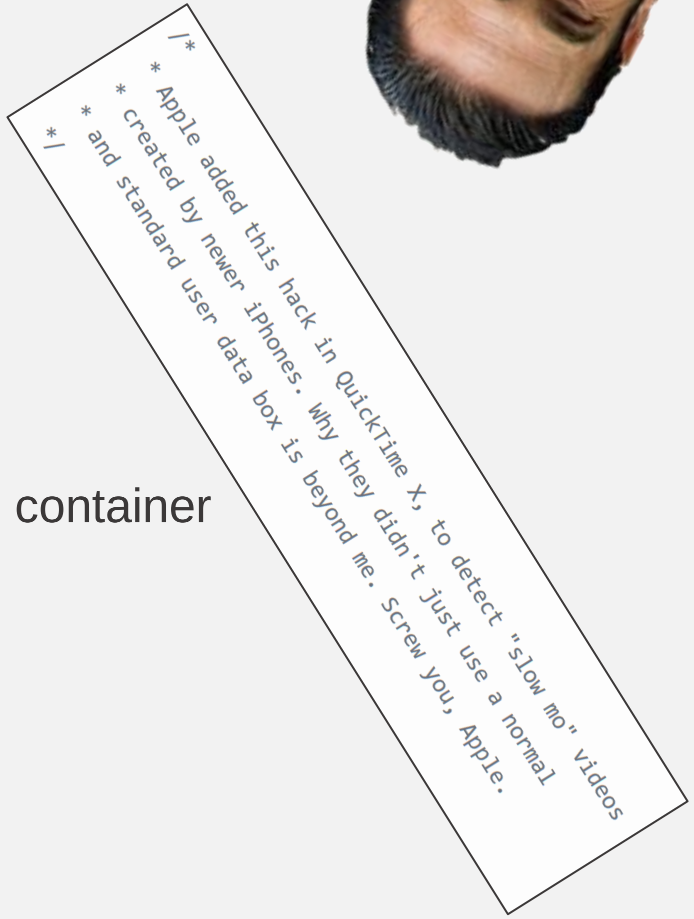

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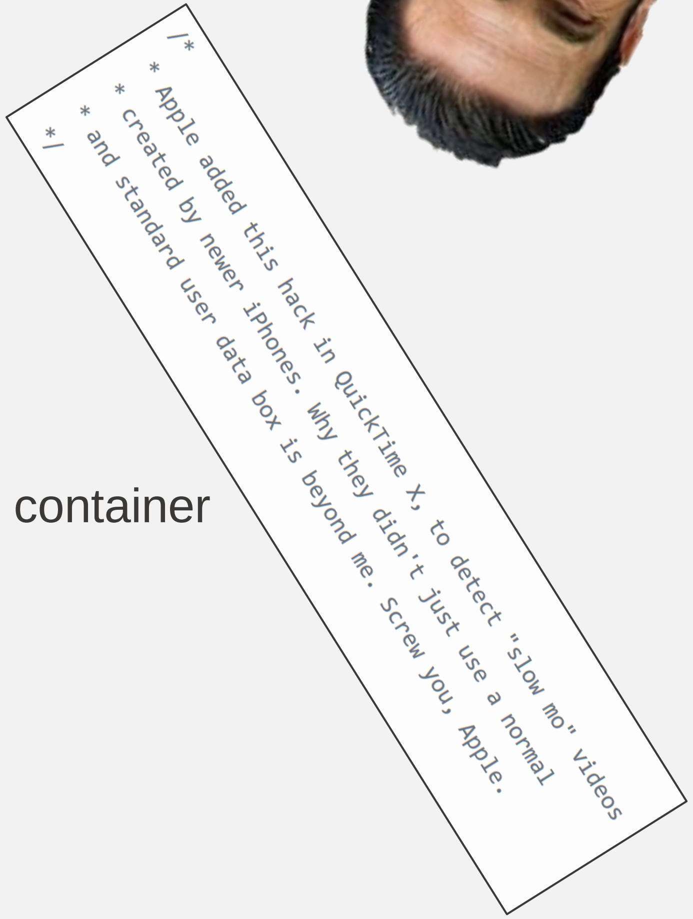

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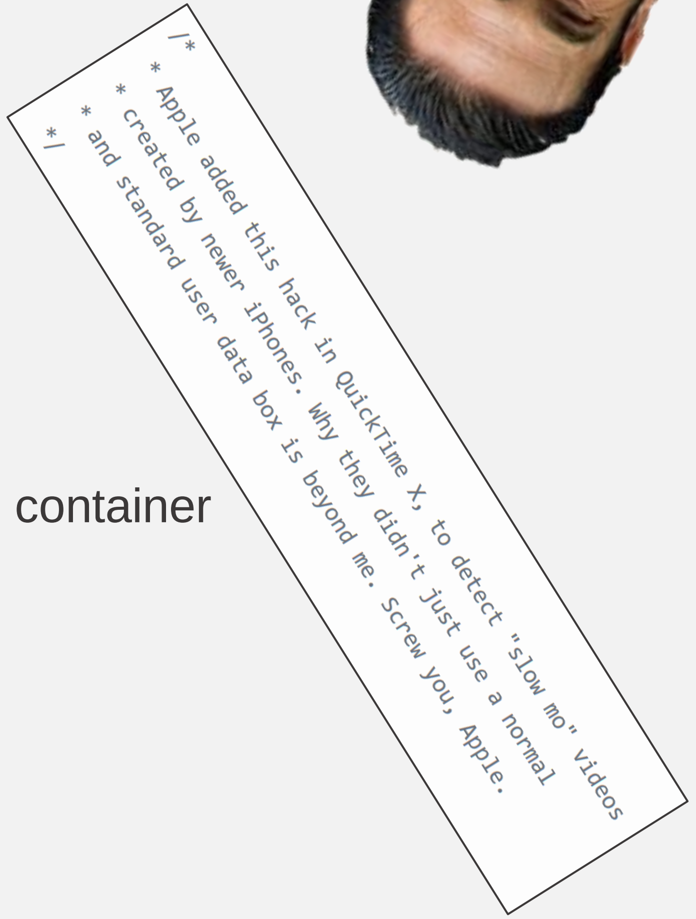
- Working around plain old bugs
  - Old Quicktime's H.264 decoder being unable to handle QPs less than 5



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Links / References

[1] zimg: https://github.com/sekrit-twc/zimg

[2] Info on libplacebo’s Möbius algorithm:

- https://github.com/mpv-player/mpv/commit/d8a3b10f45eb10fb34ce9da3a9a76e3bd8644e3d
- https://vimeo.com/album/5461208/video/293434018

[3] Demuxed 2017 Talk: https://www.youtube.com/watch?v=cRSO3RtUOOk

Questions? Heckling? “Not a question, but…”?