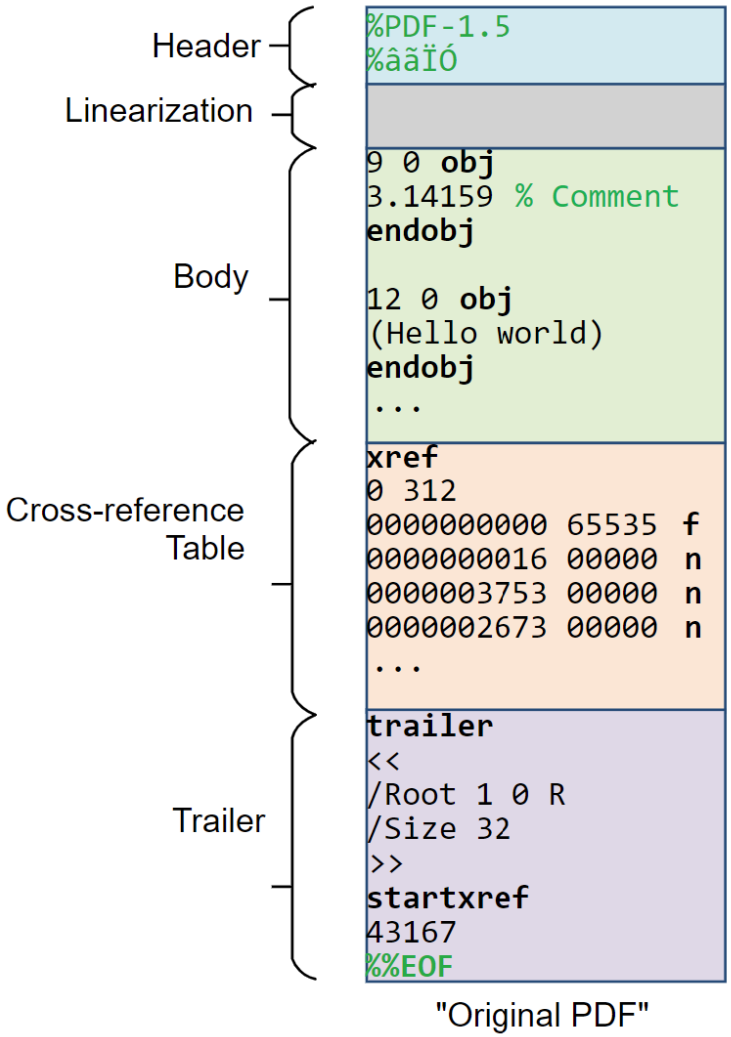
# Strengthening Weak Links in the PDF Trust Chain

Mark Tullsen, William Harris, Peter Wyatt

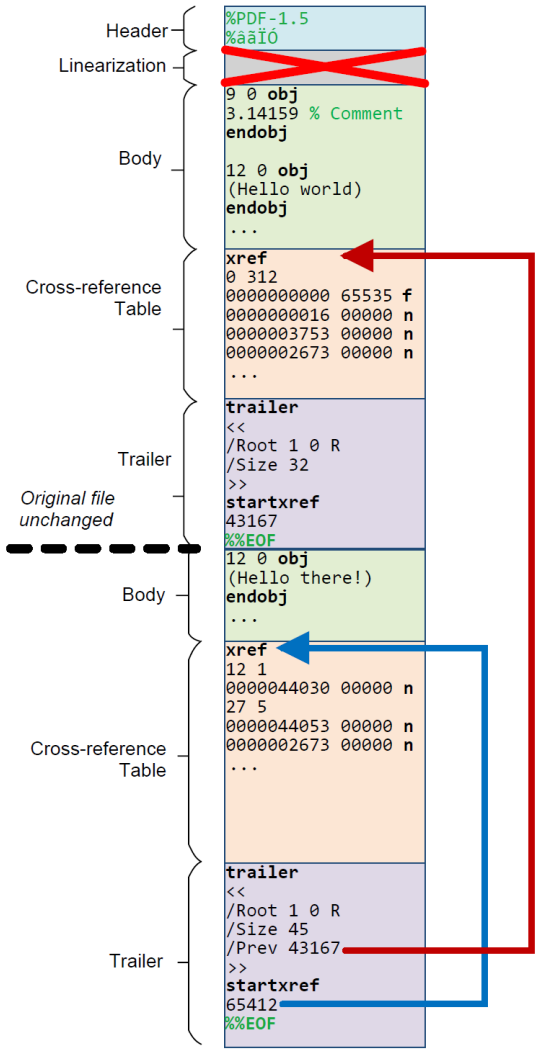
May 26, 2022

# Outline

# PDF Complexity?

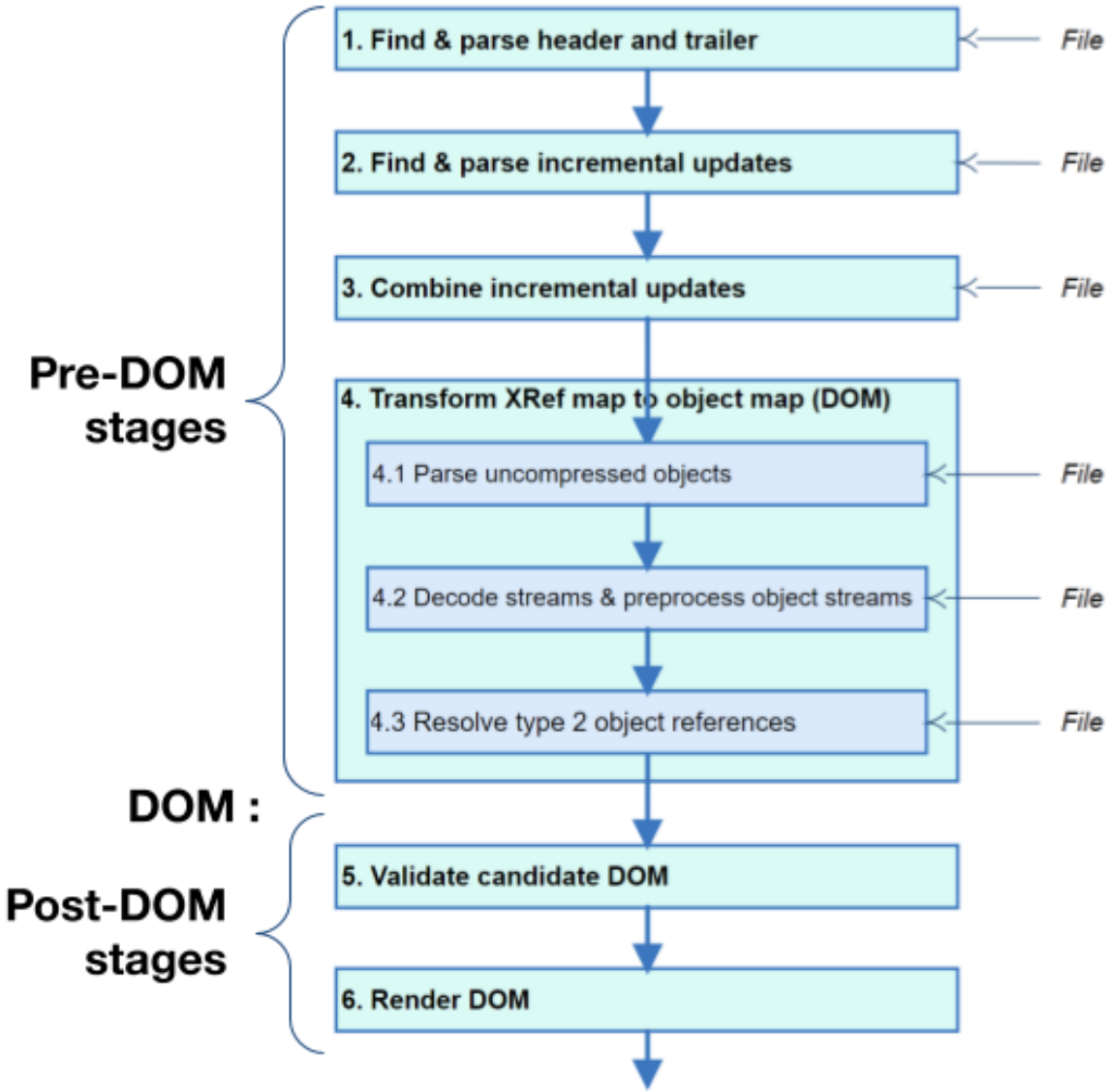



"Original PDF"




"Original PDF"
with incremental update

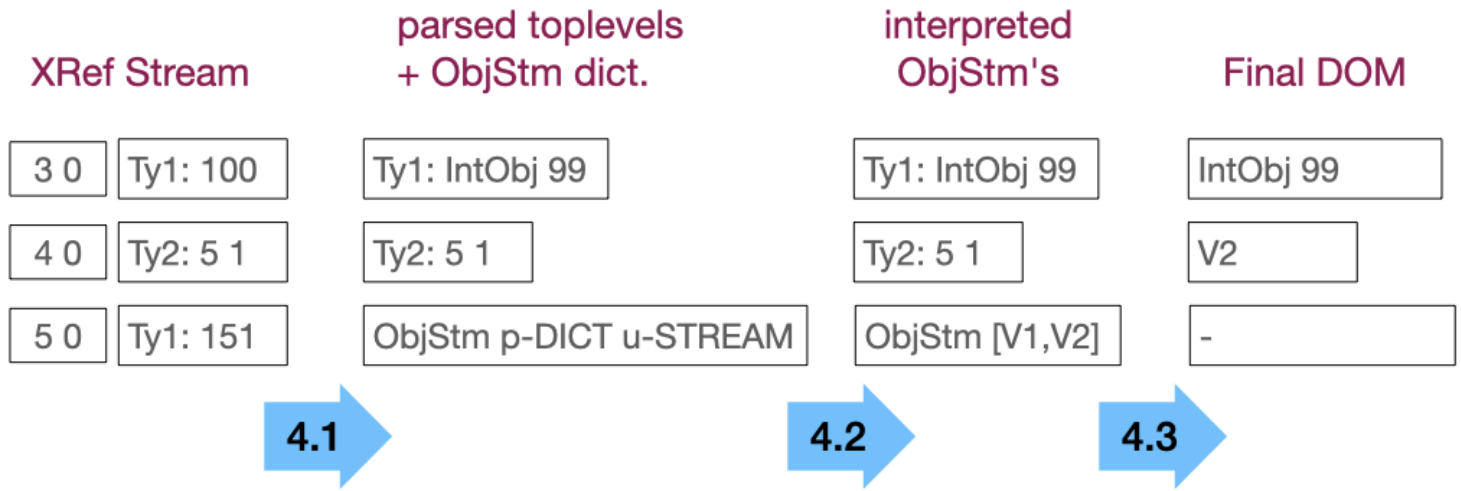
# PDF Trust Chain: Pre-DOM and Post-DOM



# Vulnerabilities Occurring Primarily Pre-DOM

- Schizophrenic files (different tools, different renderings)
- Polyglot files (file being in 2+ formats)
- Shadow attacks
  - i.e., attacker can
    - add "shadow content" that is PDF-signed,
    - after signing, can update-at-will (revealing shadow content)
    - without giving clear warnings to user.
  - possible because of ability to sign *dead objects* and *cavities*
- Multiple places for hidden/unused/malicious data in PDF
  - non-obvious places, unnoticed when "simply parsing"
  - e.g., shadow-attacks
  - dead bytes, dead objects, dead updates, dead linearization sections, etc.

# Stage 4 Sub-Stages: Transform XRef Map to Object Map

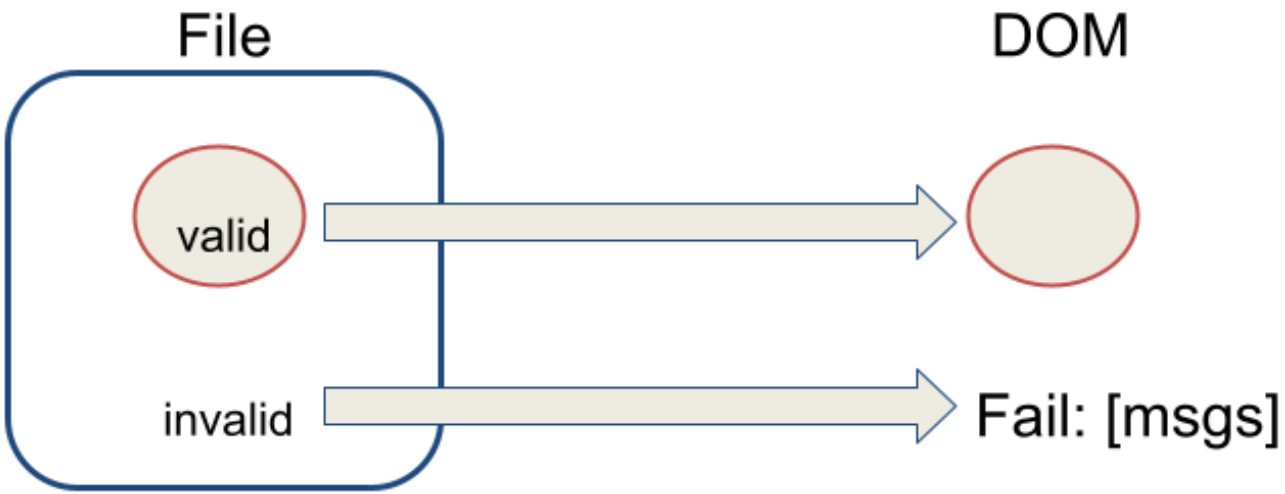



```
      ...
100   3 0 obj 99 endobj
123   % object 4 is not here
151   5 0 obj
      <<
      /Type /ObjStm
      /Length 3 0 R    % indirect!
      /N 2             % 2 objects; (potentially indirect)
      /First 10        % offset to 1st object (potentially indirect)
      >>
```

# Parser $\neq$ Validator

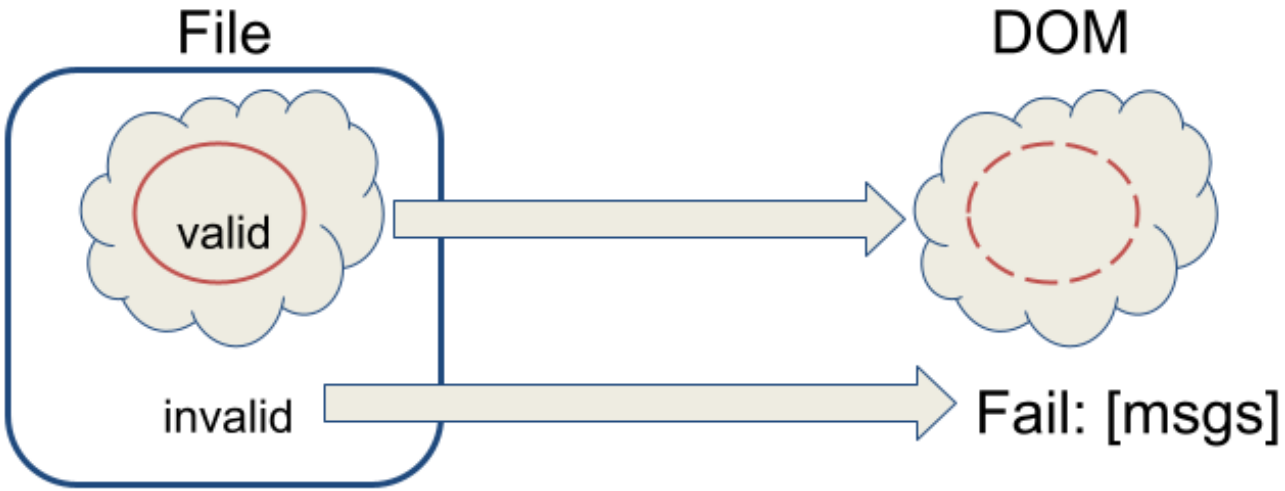
- A surprising source of mis-communication.
- ...

# A Validator (Parser ≠ Validator)



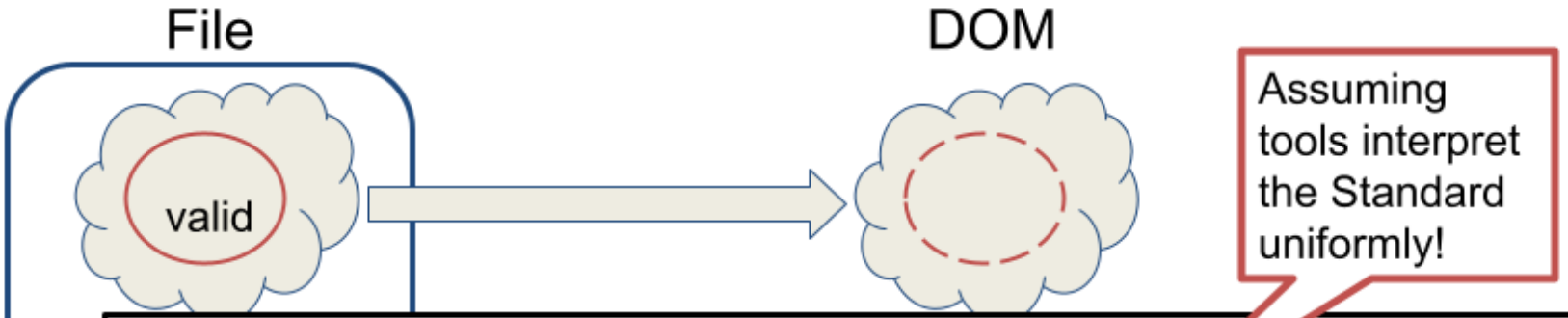

VALIDATOR: only valid PDFs can produce DOM (must Fail otherwise)

# A Parser (Parser ≠ Validator)




PARSER: efficiently, construct the correct DOM when a valid PDF

# A Very Accepting Parser (Parser ≠ Validator)




A ***Cloud*** for each parser/reader/tool:

- The tools are going to be different:
  - redundancies in format allow for different choices
  - tools allow “minor” errors
  - tool may traverse & evaluate implicit data structures differently.
- Goal for our “parser specification”:
  - Encompass any reasonable & correct cloud

# Turning Parser into Validator

Parser specification is designed to be

- understandable: clear, pure Haskell
- phased, clearly terminating (get parallelizability for free)
- very lazy "Parser" (big input cloud)

We can extend spec into a validator, orthogonally, via “validate” constructs (turning on/off on with command-line flag). E.g.,

```
do
(xrefRaw, xrefEndOff) ← pXrefRaw
validate $
   verifyXrefRaw xrefRaw -- ensures no duplicates
```

# Accomplishments

- A specification for pre-DOM parsing/computation
  - Clarifies some subtle issues in PDF Standard
  - A growing list of PDF Association "issues" that we have contributed to creating [23,24,. . . ,30]
- Cause *and* effect of
  - unique tool for displaying updates & cavities

# Future

- Not accomplished yet
  - the less interesting/subtle parts specified/implemented
  - integrated with our primitive, daedalus-generated parsers to create a tool.
- Create a full pre-DOM tool that
  - supports further PDF features (hybrids, compression, . . . )
  - add support for commonly allowed "exuberances"
  - add more "validate"s to get closer to a *validator*.

# Implementation?

Tools & renderers rarely need (*demand*) the whole PDF

- reading?
- parsing??
- semantic checks???

Thus, this

```
parsePDF :: FileData → Maybe PDFAbstractSyntax
```

is not going to be used in practice!

# One Solution . . .

- For complex formats,
  - tools are "projections": rarely used parse/validate all.
  - may have alternate "parsing paths" we want to take
    - e.g., metadata, page 1, text-only
- Shotgun Parsers?
  - . . . the deadliest of patterns: "Input data checking, handling interspersed with processing logic"
- I.e., we provide multiple parsers where the following is interspersed through code and the relation between these is not specified:

```
parseA :: Offset → IO A
parseB :: Offset → IO B
parseC :: Offset → IO C
validateA :: A → IO ()
validateB :: A → B → IO ()
```

# Better Solution, Parser as API

We provide four inter-dependent calls (not *entry points*):

```
parseHdrTrlr :: FileData → IO HdrTrlr
parseUpdates :: HdrTrlr → IO [Updates]
createXRef   :: [Updates] → IO XRef
derefObjId   :: ObjId → XRef → IO PdfValue
```

(The returned types can be as abstract as we wish.)

Using this, we write abstractions on the above:

```
getInitialUpdate :: FileData → IO XRef
getRootValue     :: HdrTrailer → XRef → PdfValue
getPageTree      :: XRef → Tree PdfValue
```