
Preservation planning 2

What to decide and how
What to measure and how
Monitoring and Scalability

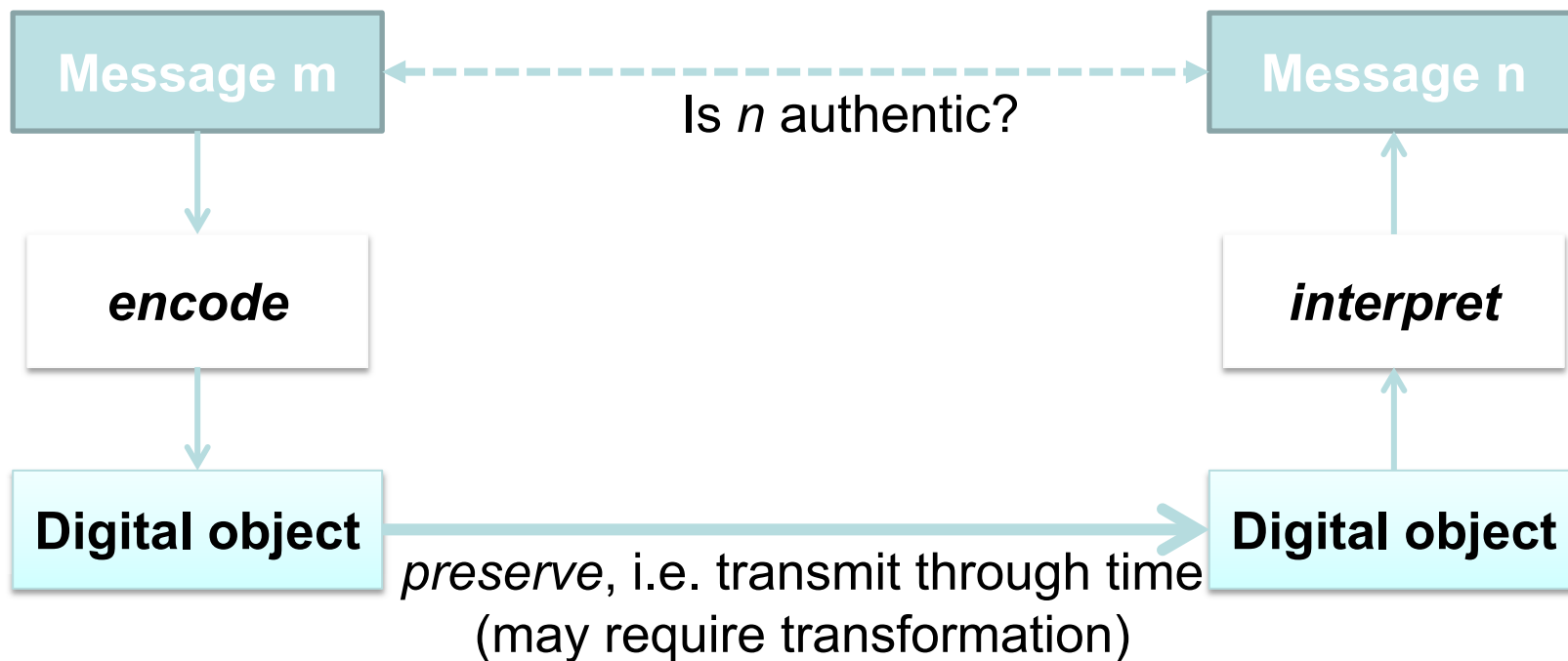
May 3, 2012

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www.ifs.tuwien.ac.at/~becker

Digital preservation is communication...



... But at the time of reception

there is no message *m* any more

there may be no sender (any more)

there may be no encoder to check against

there may be no decoder

the recipient may not be the original addressee

- The mission of digital preservation
 - keep content authentic and understandable for a user community over time
- The mission of preservation *planning*
 - What to do and how
 - Defining the right courses of actions
 - Questions:
 - Which action to take in a scenario with given constraints and goals?
 - How to ensure trust?
 - How to enable scalability?
 - How to ensure continuous alignment over time?

- Core operations for preservation
 - Analyse content
 - Perform preservation actions
 - Perform Quality Assurance
 - Manage metadata
 - Report

- Several actions available (migration, emulation, ...)
- Challenges:
 - Quality varies across tools
 - Properties vary across content
 - Usage varies across communities
 - Requirements vary across scenarios
 - Risk tolerance varies across collections
 - Preferences and constraints vary across organisations
 - Cost structures and compatibility varies across environments
 - Constraints, priorities and requirements shift constantly

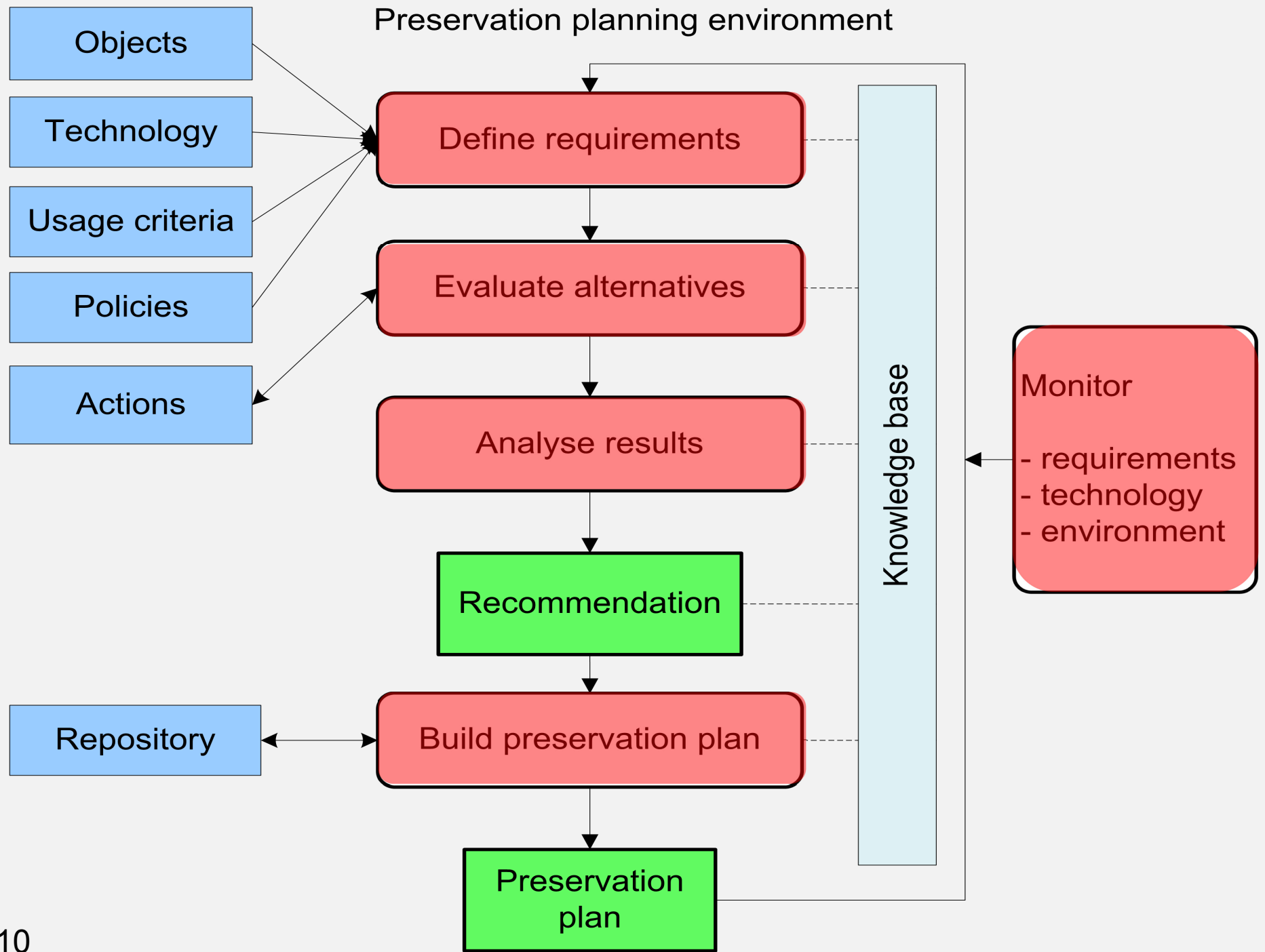
- **How can we select the optimal preservation action for a given setting?**
 - What are the drivers and constraints on the decision space?
 - What are the goals and objectives?
 - What are the factors influencing the decision makers' preferences?
 - How can we model multiple competing objectives and requirements?
 - How should we evaluate software components?

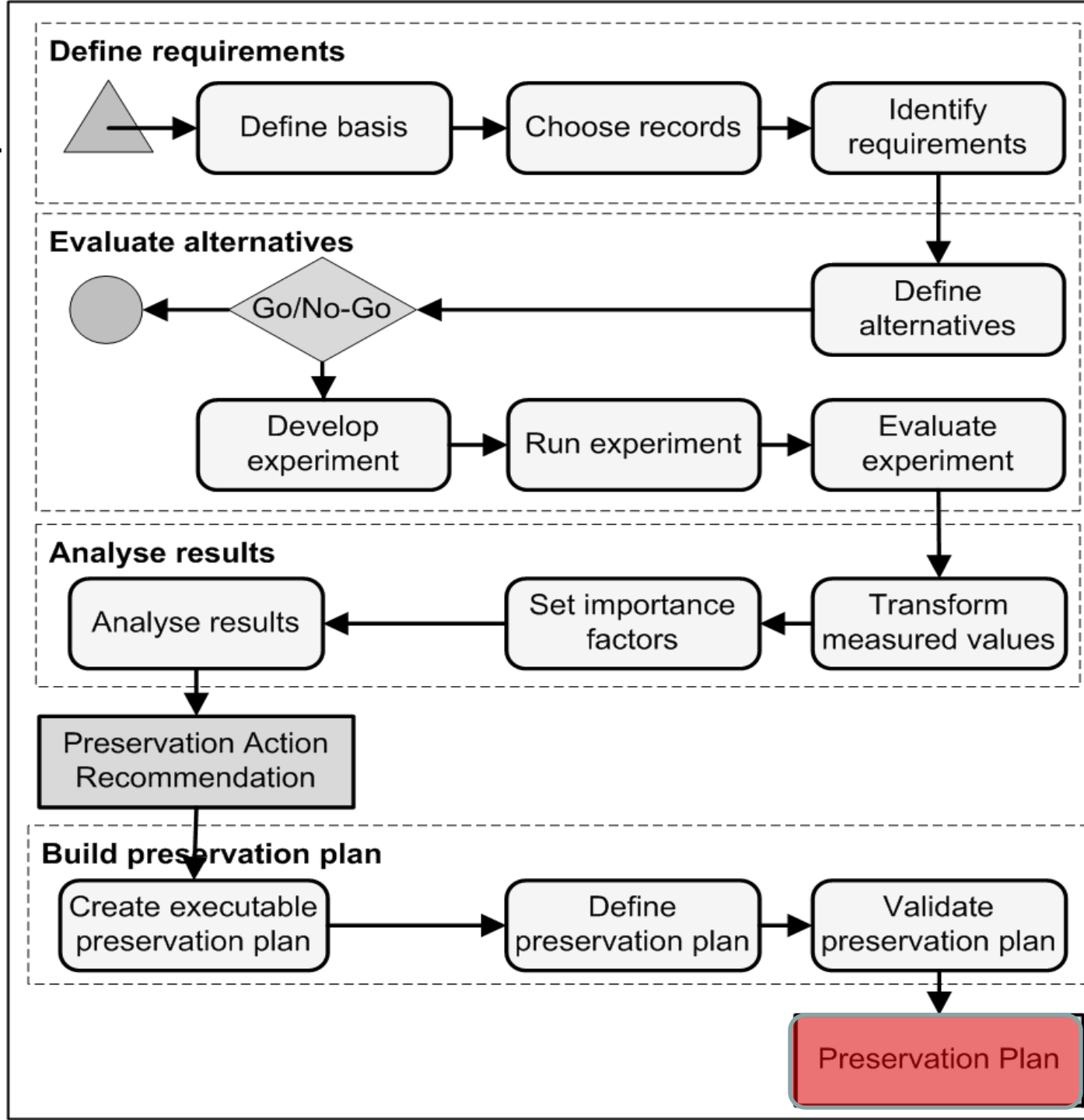
- **How can we ensure trustworthy preservation planning?**
 - What are the requirements on trust that need to be addressed?
 - What decision steps and evidence need to be documented?
 - What are the aspects that a plan needs to address, and what are the elements needed to cover them?
 - How can we ensure reliable evaluation procedures and repeatable evidence?

- **How can we ensure that decision processes scale up?**
 - How can we automate decision making?
 - How can we integrate continuous monitoring?
 - Which properties can be measured automatically, and how?
 - How can we create a controlled environment for observing the behaviour of components in a reproducible way?

- Repeatable, standardized planning workflow
- A weighted hierarchy of objectives
 - Measurable criteria on the leaf level of the tree
 - Utility functions make criteria comparable
- Controlled experimentation on sample content
 - Evidence-based decision making
- Standardized structure for plan specification
 - Transparency and documentation
 - Comparability across scenarios
 - Integration with repository systems
- Planning tool Plato guides, validates, documents
 - www.ifs.tuwien.ac.at/dp/plato
- Automation: Reduce manual effort

Preservation planning environment





What is a preservation plan?

- ‘A **preservation plan** defines a series of preservation actions to be taken by a responsible institution to address an identified risk for a given set of digital objects or records (called collection).’
- The Preservation Plan takes into account the preservation **policies, legal obligations, organisational and technical constraints, user requirements and preservation goals.**
- It also **describes the preservation context**, the evaluated alternative preservation strategies and the resulting decision for one strategy, including the rationale of the decision.

What is *in* a preservation plan?

- Definition of scope and context
 - What to preserve and why
- Definition of objectives
 - What to achieve
- Set of actions, evaluation and recommendation
 - How to preserve it and why
- Documentation of reasons
 - Why did we decide what
- Conditions for QA and monitoring
 - What to look out for

Digital Preservation drivers

Table 4 - DP drivers as specified in the SHAMAN Reference Architecture

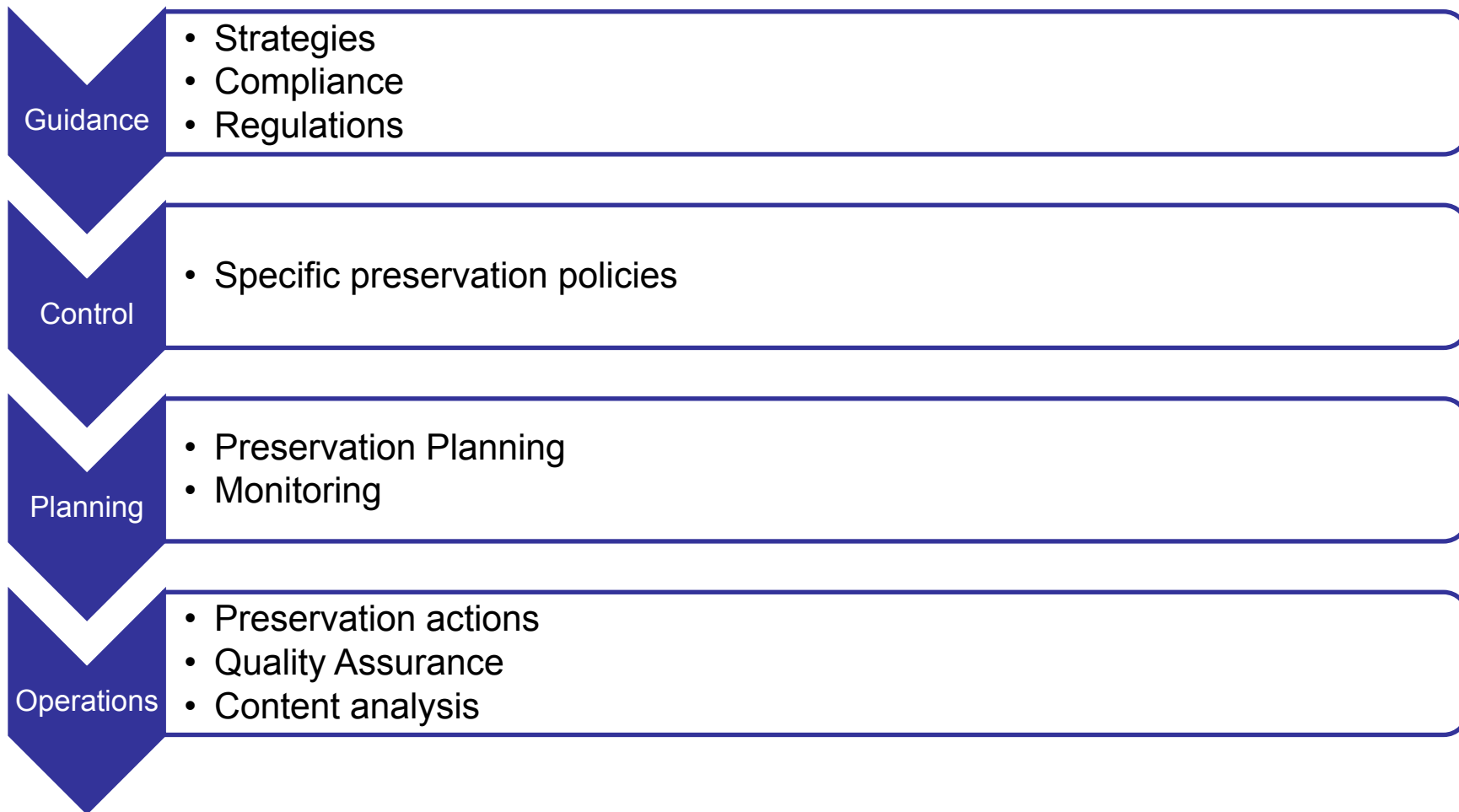
Internal	Business Vision	Goals, Scope of designated community, etc.
	Resources	Infrastructure (e.g., operational costs, expertise needed), Hardware (e.g., operational costs, technological capability), Software (e.g., operational costs, technological capability), Staff (e.g., expertise and qualifications, commitment)
	Data	Volume, Structure, Representation, Semantics, etc.
	Processes	Dependencies, Responsibilities, Alignment, etc.
External	Producers	Demand satisfactions, Content, Technology, Trust and reputation
	User community	Technology, Knowledge, Demand satisfaction, Trust and reputation
	Contracts	Deposit, Supplier and service, Interoperability, Access, etc.
	Supply	Technology, Services, People
	Competition	Overlap of: Services, Content, User community, Producers, Technology, Mandate, Rights, Funding, Capabilities
	Regulation and mandate	Regulation/Legal constraints, Embedding organization regulation, Mandate, Rights and ownership, Certification, Funding

A scenario in a National Library

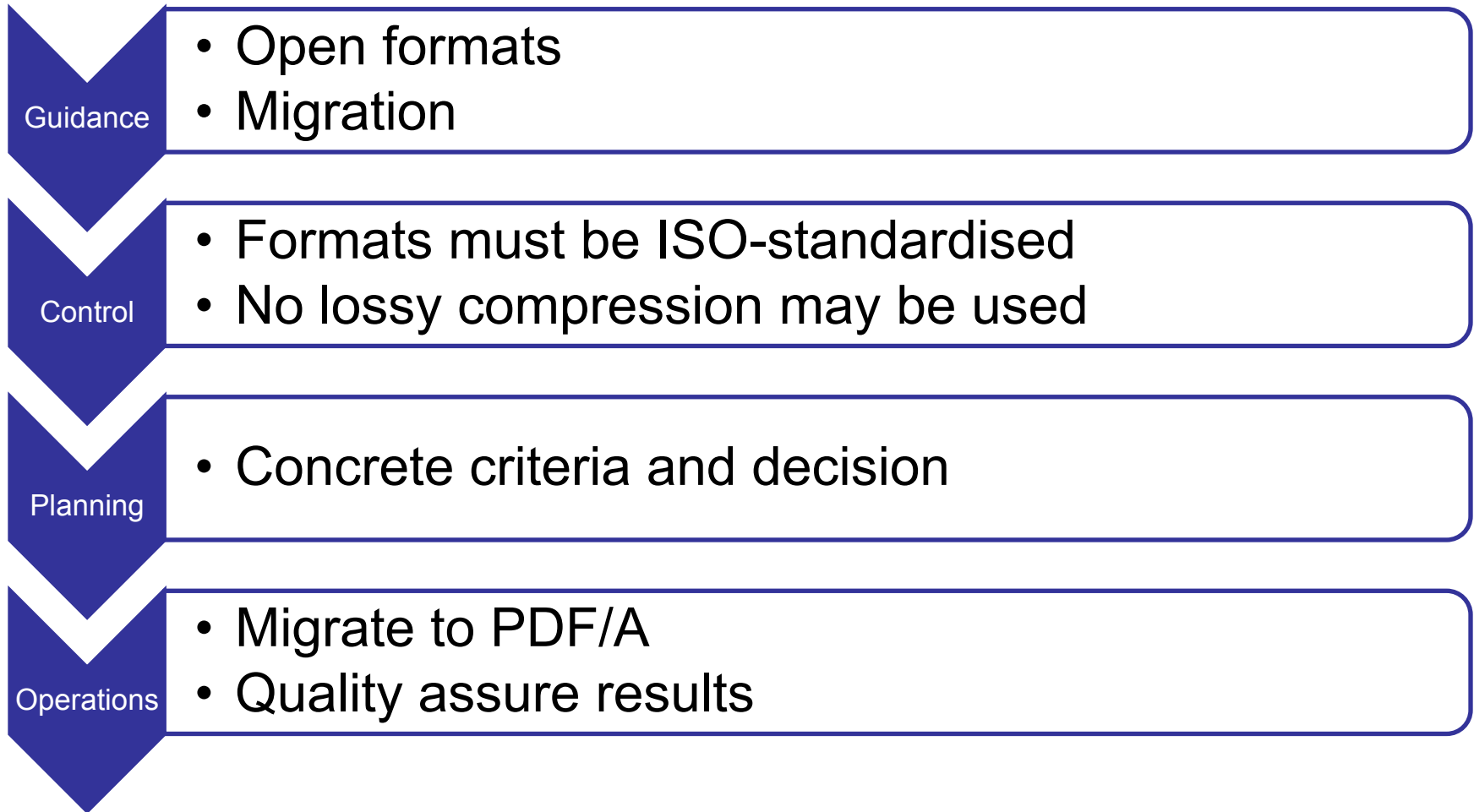
Scanned old print material, digitally recorded AV broadcast material, web archive
 Legal mandate for long-term preservation and access, IT department in-house
 Drivers and constraints?

Internal	Business Vision	Goals, Scope of designated community, etc.
	Resources	Infrastructure (e.g., operational costs, expertise needed), Hardware (e.g., operational costs, technological capability), Software (e.g., operational costs, technological capability), Staff (e.g., expertise and qualifications, commitment)
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Levels of control



From guidance to action



Select content type

- Legal documents from the enterprise archive



Select properties

- Property set determined by type “documents” (page count, ...)



High-level issue detection

- Object-level policy violations: Validity, encryption, **renderability**,...
- Collection-level: format normalisation...



Select scoping property

- Subformat: PDF 1.2...
- Other properties: all protected documents....

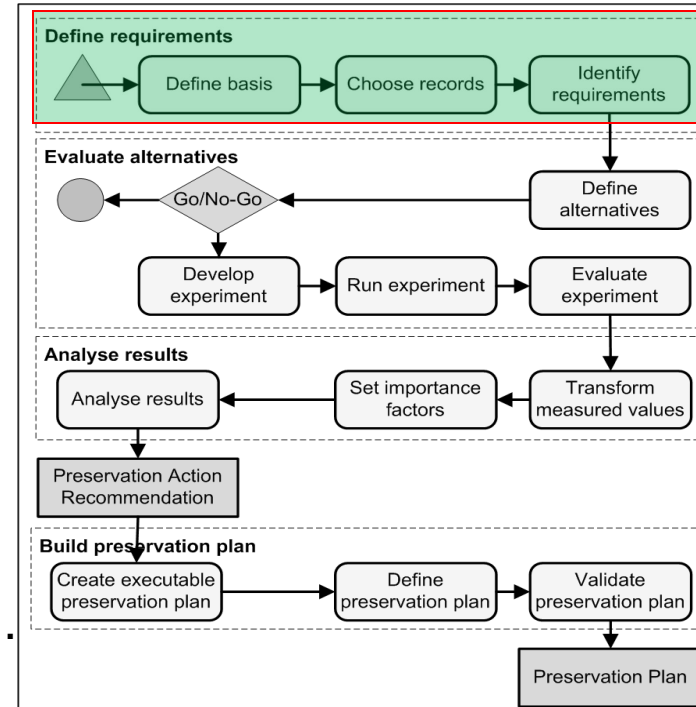


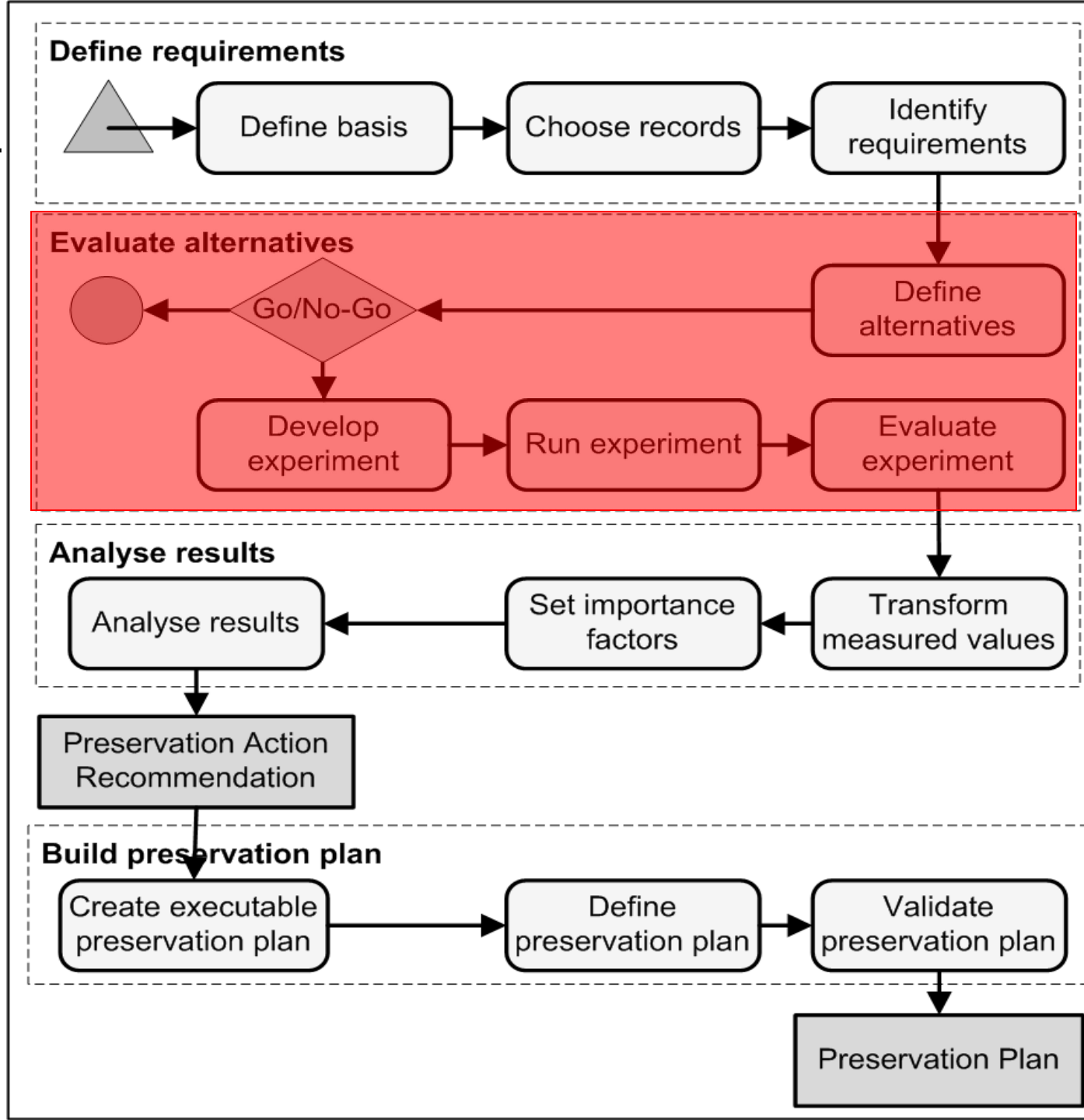
Select samples

- Single dimension: page count, size, age, validity...
- Multiple dimensions: Largest invalid, oldest protected ...

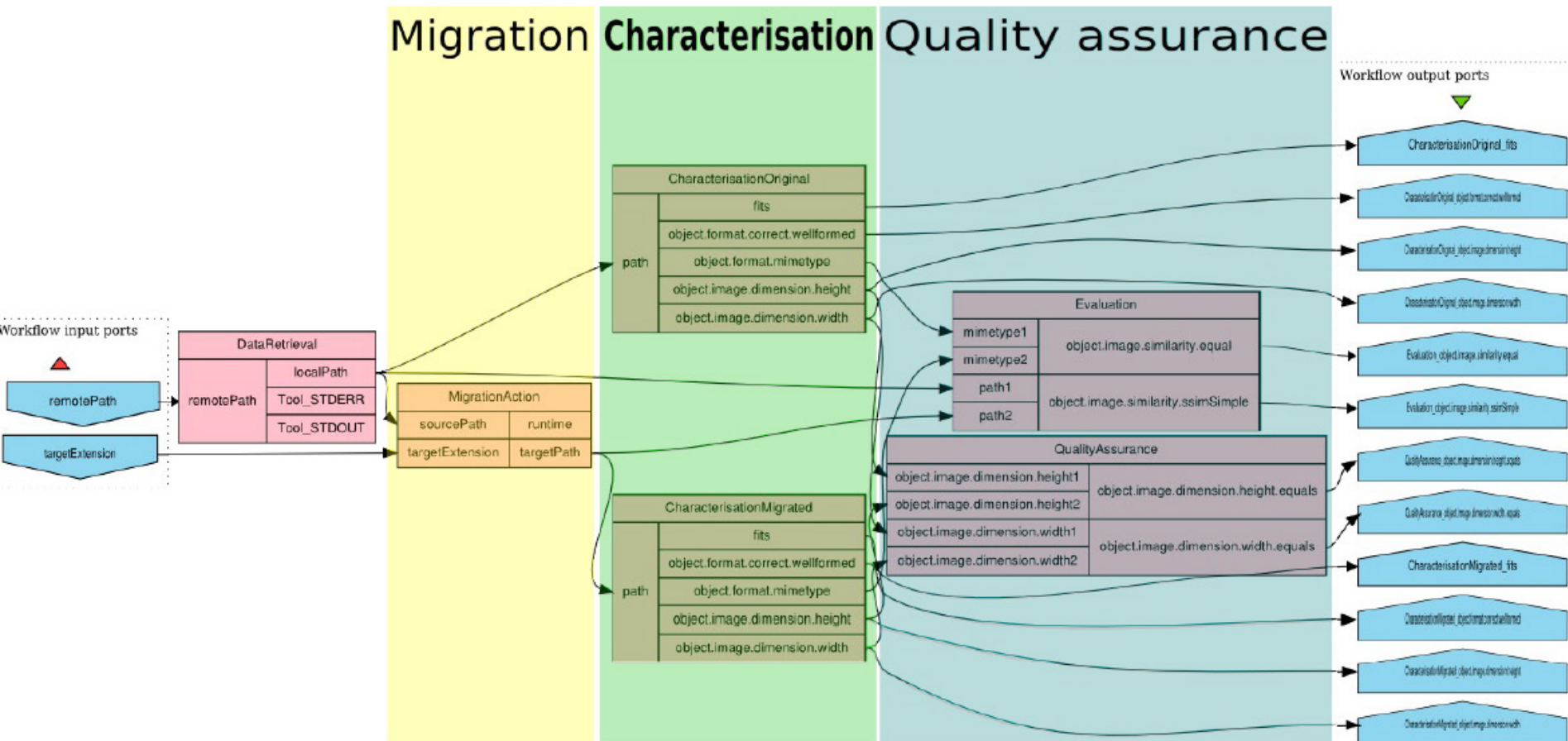
Results of Phase 1

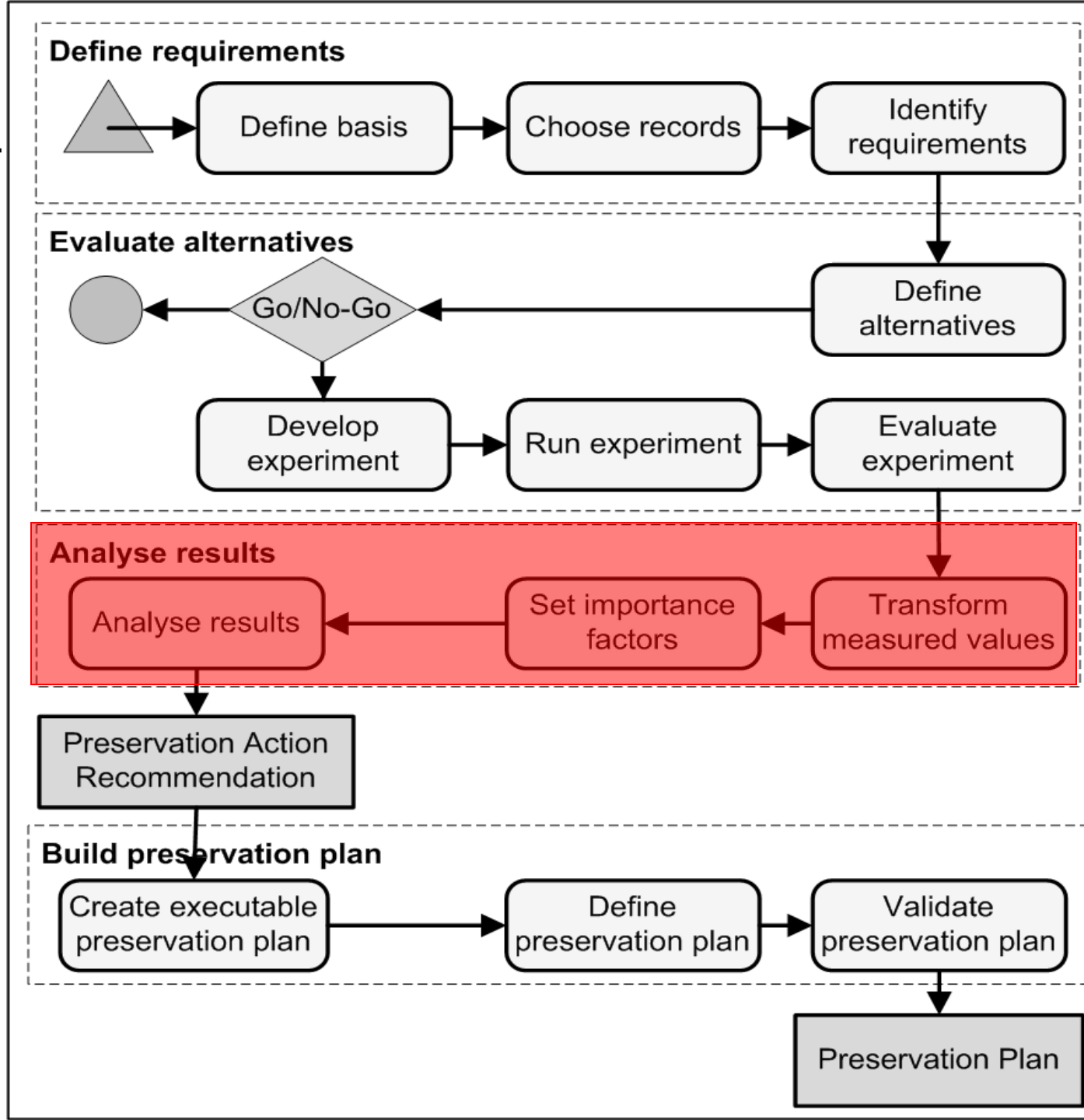
- Defined and documented the context of a preservation problem
 - Which types of objects
 - Which environment
 - What are the obligations and constraints
- Defined and documented representative samples for performing experiments
- Defined and documented goals and objectives
 - From goals and requirements to measurable criteria

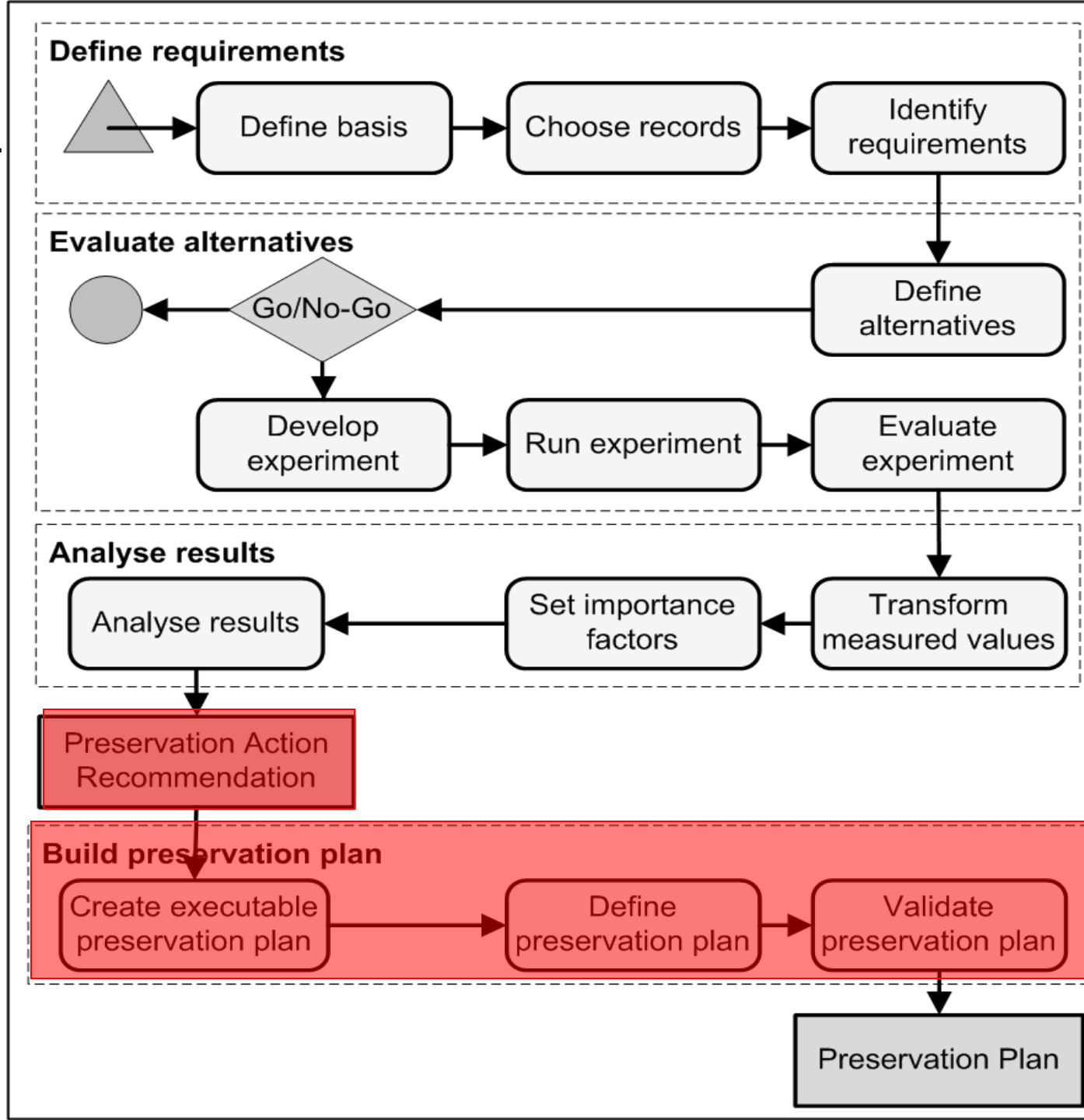




A planning experiment





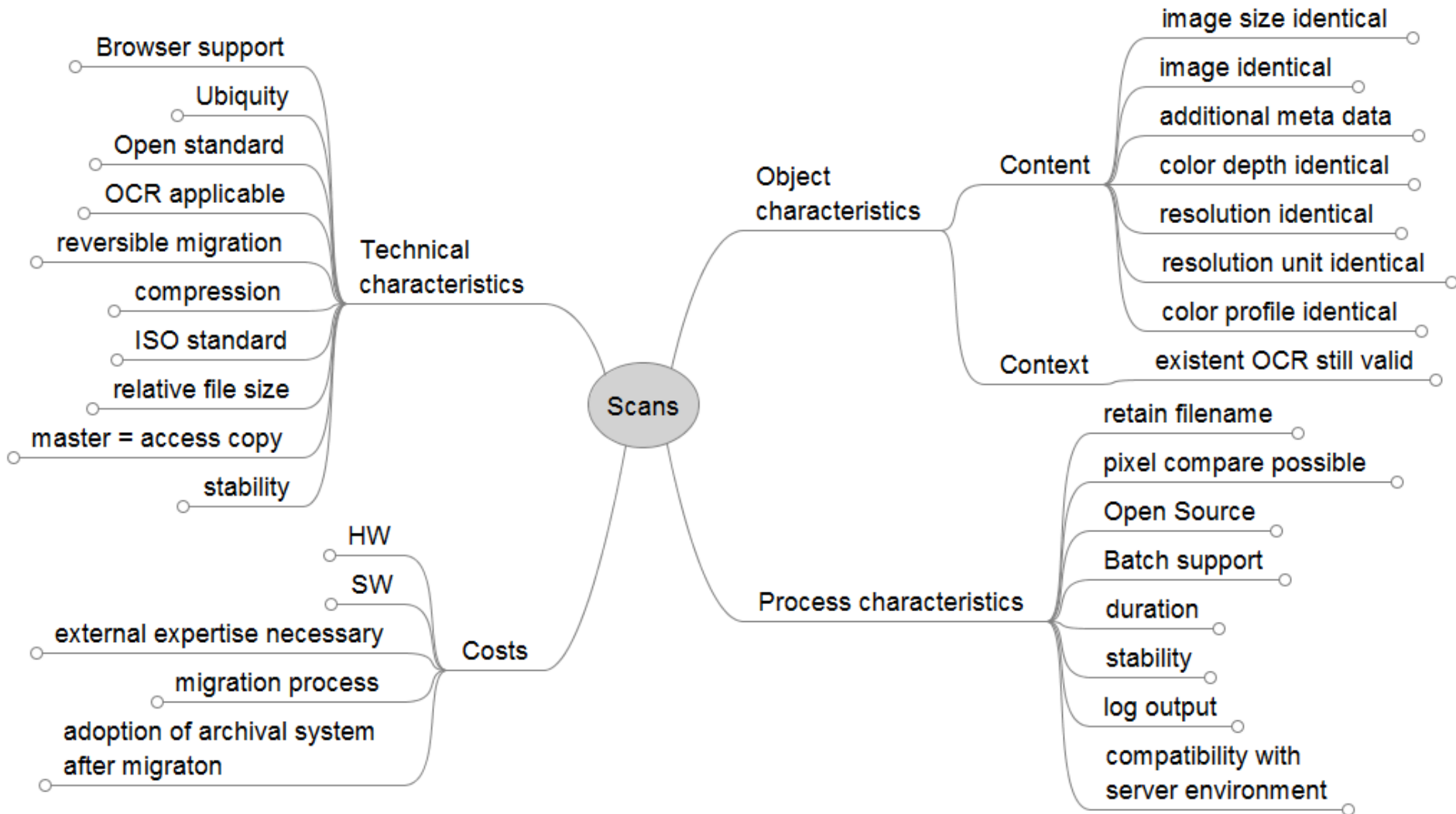


Four cases, three solutions: Scanned images

- Bavarian State Library, 72TB TIFF6: *Leave and monitor*
- British Library, 80TB TIFF5: *Migrate to JP2 (ImageMagick)*
- Royal Library of Denmark, ~10.000 aerial photographs in TIFF6: *Leave and monitor*
- State and University Library Denmark, scanned yearbooks in GIF: *Migrate to TIFF 6*

Scenario	Chosen action	Main reasons
72 TB scanned book pages in TIFF6	Leave unchanged and monitor	Color profile complications, lack of JP2 browser support, Process costs
80 TB scanned newspapers in TIFF5	Migrate to JP2	Storage costs, Standardization
Aerial photographs in TIFF6	Leave unchanged and monitor	Lack of JP2 browser support, Process costs






























































































Scanned books requirements



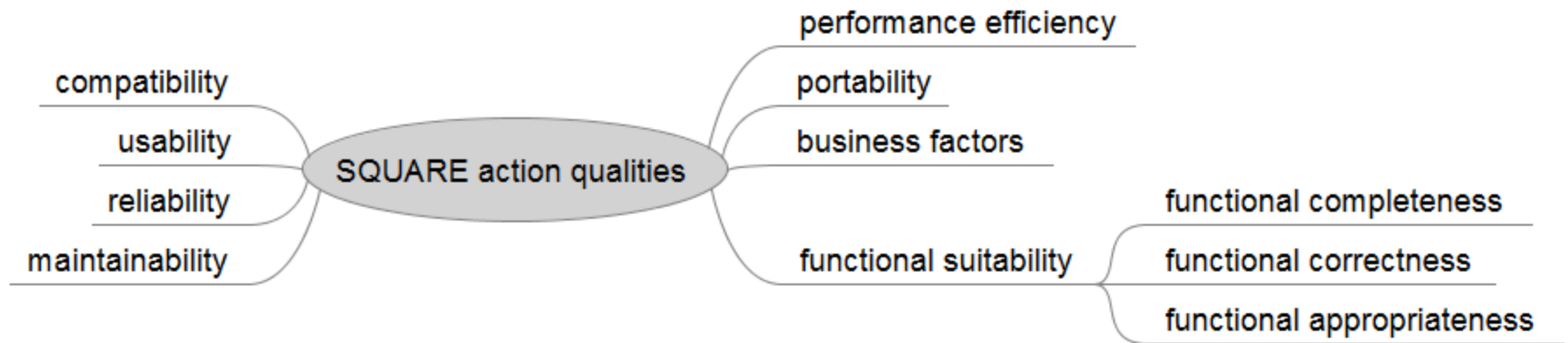
Scanned books results

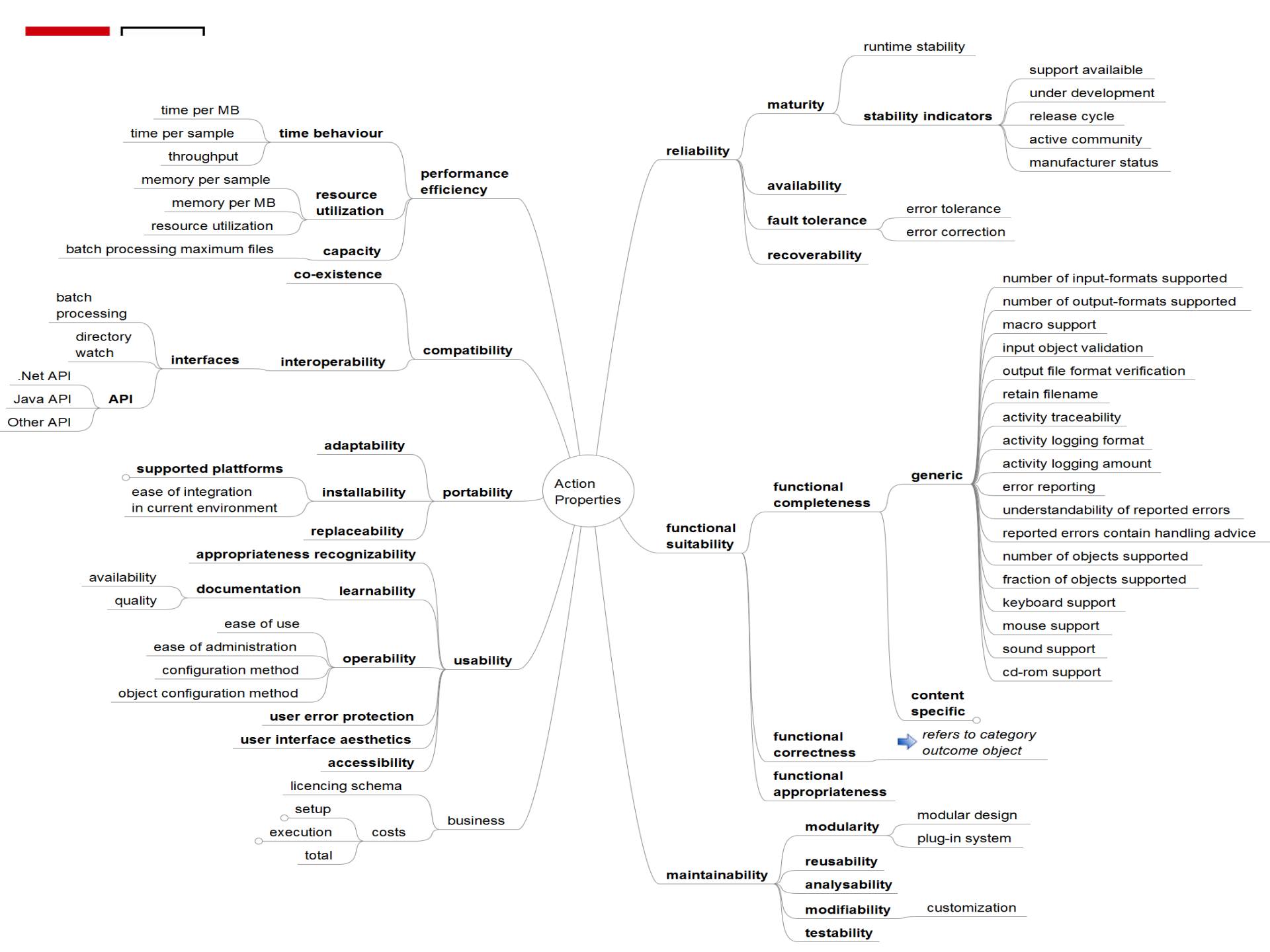
Results: Weighted multiplication

Result-Tree with all Alternatives, Aggregation method: Weighted multiplication

Node	Results															
Scans	<table><tr><td>Keep status quo:</td><td>4.50</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>3.71</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>0.00</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>3.68</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>3.65</td><td></td></tr></table>	Keep status quo:	4.50		ImageMagick - TIFF to JP2:	3.71		GraphicsMagick - TIFF to JP2:	0.00		Kakadu - TIFF to JP2:	3.68		GeoJasper - TIFF to JP2:	3.65	
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GeoJasper - TIFF to JP2:	3.65															
Object characteristics	<table><tr><td>Keep status quo:</td><td>1.50</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>1.38</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>0.00</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>1.38</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>1.38</td><td></td></tr></table>	Keep status quo:	1.50		ImageMagick - TIFF to JP2:	1.38		GraphicsMagick - TIFF to JP2:	0.00		Kakadu - TIFF to JP2:	1.38		GeoJasper - TIFF to JP2:	1.38	
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GeoJasper - TIFF to JP2:	1.38															
Content	<table><tr><td>Keep status quo:</td><td>2.24</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>1.63</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>0.00</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>1.63</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>1.63</td><td></td></tr></table>	Keep status quo:	2.24		ImageMagick - TIFF to JP2:	1.63		GraphicsMagick - TIFF to JP2:	0.00		Kakadu - TIFF to JP2:	1.63		GeoJasper - TIFF to JP2:	1.63	
Keep status quo:	2.24															
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image size identical	<table><tr><td>Keep status quo:</td><td>1.19</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>1.19</td><td></td></tr></table>	Keep status quo:	1.19		ImageMagick - TIFF to JP2:	1.19		GraphicsMagick - TIFF to JP2:	1.19		Kakadu - TIFF to JP2:	1.19		GeoJasper - TIFF to JP2:	1.19	
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additional meta data	<table><tr><td>Keep status quo:</td><td>1.19</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>1.08</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>1.08</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>1.08</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>1.08</td><td></td></tr></table>	Keep status quo:	1.19		ImageMagick - TIFF to JP2:	1.08		GraphicsMagick - TIFF to JP2:	1.08		Kakadu - TIFF to JP2:	1.08		GeoJasper - TIFF to JP2:	1.08	
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Kakadu - TIFF to JP2:	1.08															
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color depth identical	<table><tr><td>Keep status quo:</td><td>1.19</td><td></td></tr><tr><td>ImageMagick - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>GraphicsMagick - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>Kakadu - TIFF to JP2:</td><td>1.19</td><td></td></tr><tr><td>GeoJasper - TIFF to JP2:</td><td>1.19</td><td></td></tr></table>	Keep status quo:	1.19		ImageMagick - TIFF to JP2:	1.19		GraphicsMagick - TIFF to JP2:	1.19		Kakadu - TIFF to JP2:	1.19		GeoJasper - TIFF to JP2:	1.19	
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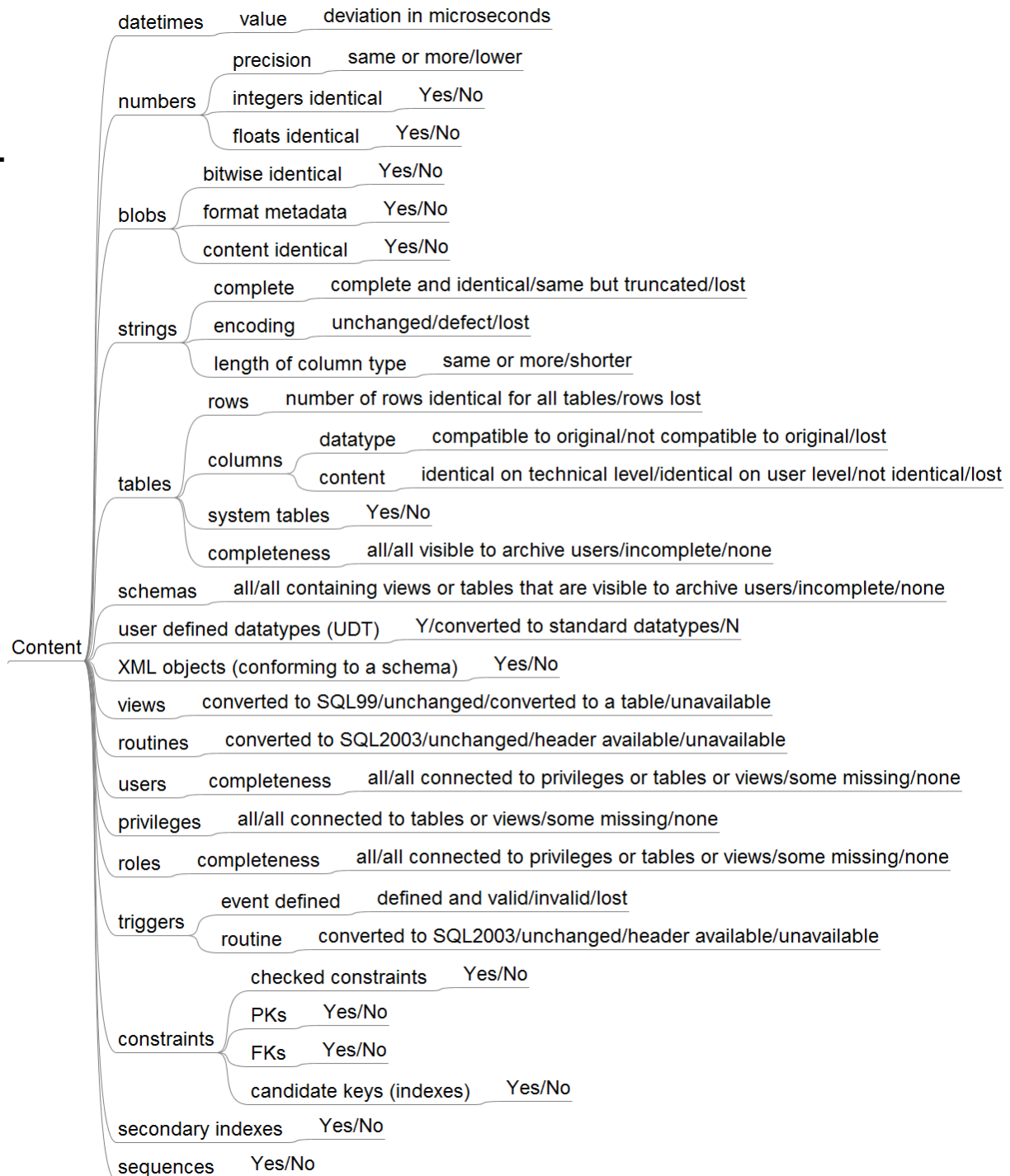
- ISO 25010 SQUARE: Software quality model
 - (*Business factors not part of SQUARE*)
- Need to define indicators and metrics for specific domain





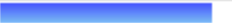

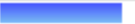


Database study

Content branch



Results: Weighted multiplication

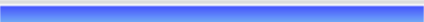

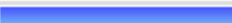

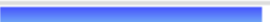









Result-Tree with all Alternatives, Aggregation method: Weighted multiplication

Node	Results
<input checked="" type="checkbox"/> Requirements	Archive to XML: 3.88  Keep original DB:3.72  CSV export: 0.00
<input checked="" type="checkbox"/> Object characteristics	Archive to XML: 2.14  Keep original DB:2.32  CSV export: 0.00
<input checked="" type="checkbox"/> Content	Archive to XML: 2.38  Keep original DB:2.51  CSV export: 0.00
<input checked="" type="checkbox"/> appearance	Archive to XML: 1.14  Keep original DB:1.16  CSV export: 1.06 
<input checked="" type="checkbox"/> context	Archive to XML: 1.23  Keep original DB:1.17  CSV export: 0.88 
<input type="checkbox"/> behaviour	Archive to XML: 1.00  Keep original DB:1.12  CSV export: 1.00 
<input checked="" type="checkbox"/> Format characteristics	Archive to XML: 1.36  Keep original DB:1.20  CSV export: 1.13 
<input checked="" type="checkbox"/> Tool characteristics	Archive to XML: 1.34 

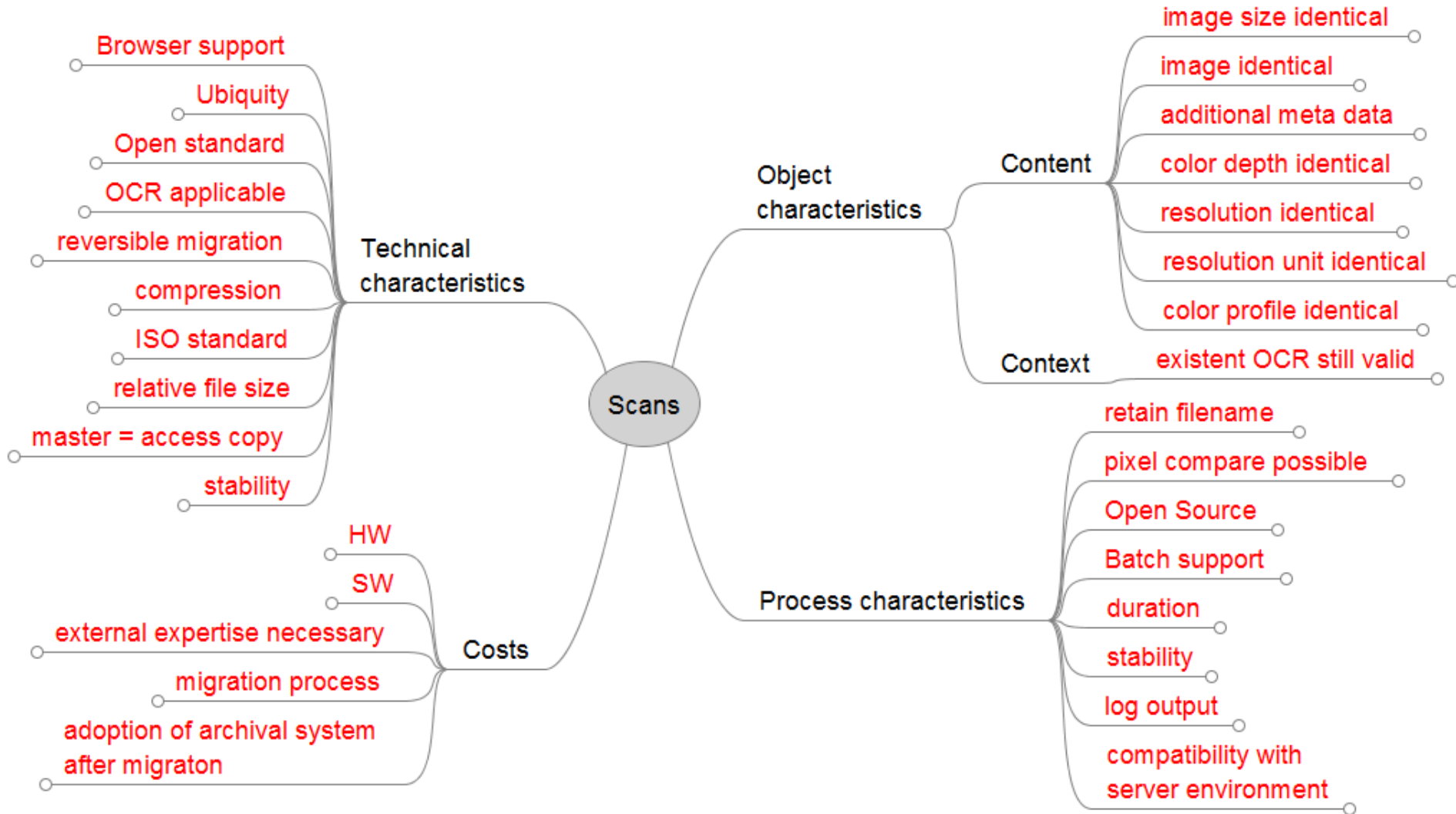
Results: Weighted sum

Result-Tree with all Alternatives, Aggregation method: Weighted sum.

This tree contains only strategies that do not have knock-out evaluation criteria; see above

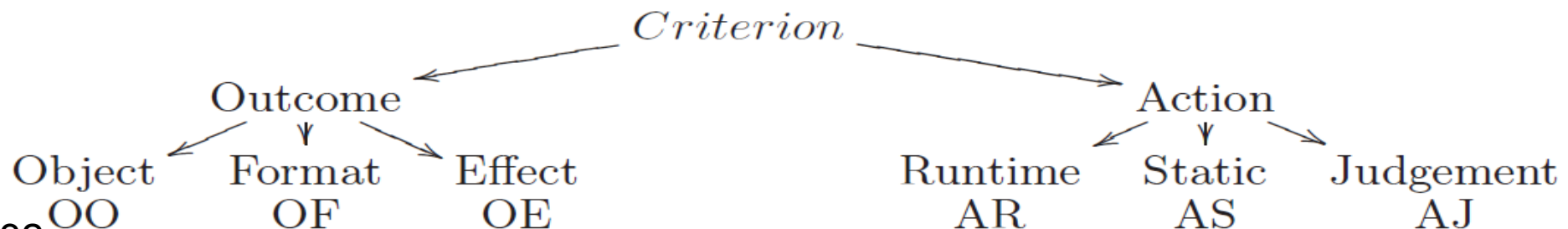
Node	Results
<input checked="" type="checkbox"/> Requirements	Archive to XML: 4.25  Keep original DB:4.07 
<input checked="" type="checkbox"/> Object characteristics	Archive to XML: 2.40  Keep original DB:2.60 
<input checked="" type="checkbox"/> Content	Archive to XML: 2.63  Keep original DB:2.76 
<input checked="" type="checkbox"/> appearance	Archive to XML: 0.41  Keep original DB:0.45 
<input checked="" type="checkbox"/> context	Archive to XML: 0.69  Keep original DB:0.57 
<input type="checkbox"/> behaviour	Archive to XML: 0.07  Keep original DB:0.35 
<input checked="" type="checkbox"/> Format characteristics	Archive to XML: 0.95  Keep original DB:0.57 

Scanned books requirements

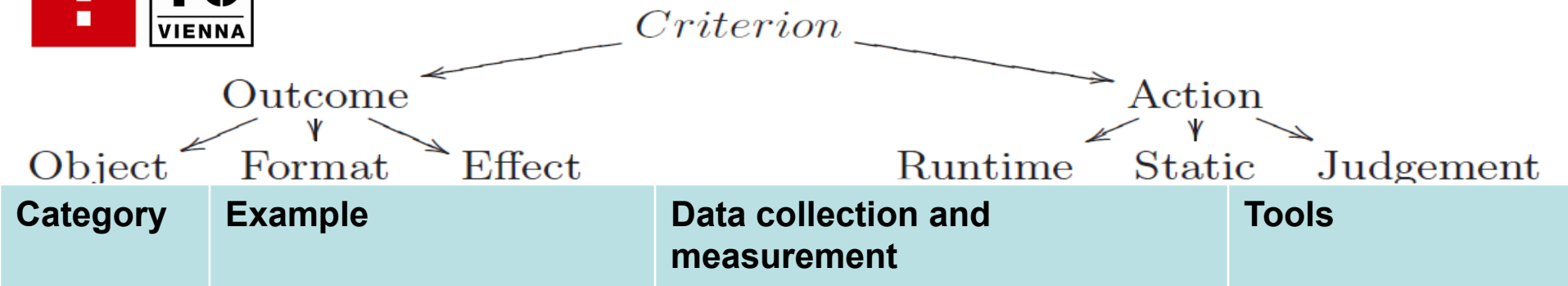


Decision criteria: What to measure?

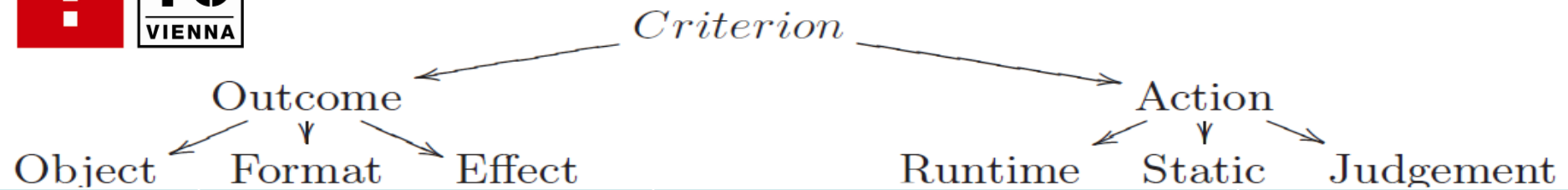
- Each criterion concerns either the action or its outcome
- **Outcome**
 - **Object** (authenticity, editability, ...)
 - **Format** (licensing, standardisation, complexity...)
 - **Effect** (Costs...)
- **Action**
 - **Runtime** properties (performance, stability, logging...)
 - **Static** (price, license...)
 - **Judgement** (configuration interface usability...)



How to measure?

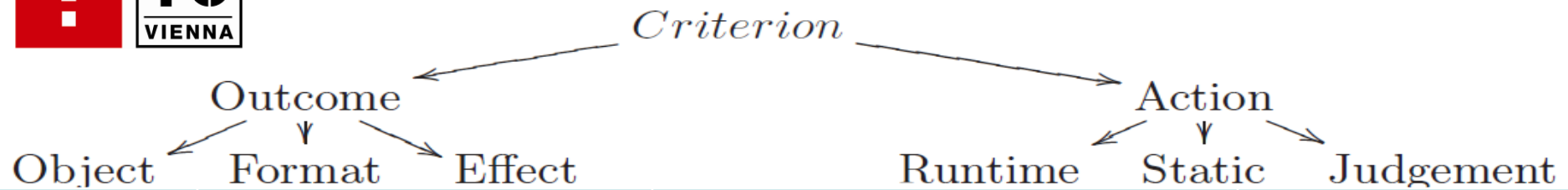


How to measure?



Category	Example	Data collection and measurement	Tools
Outcome Object	Image pixelwise identical Footnotes preserved	Measurements of output and input, comparison	FITS, JHove, image comparison...

How to measure?



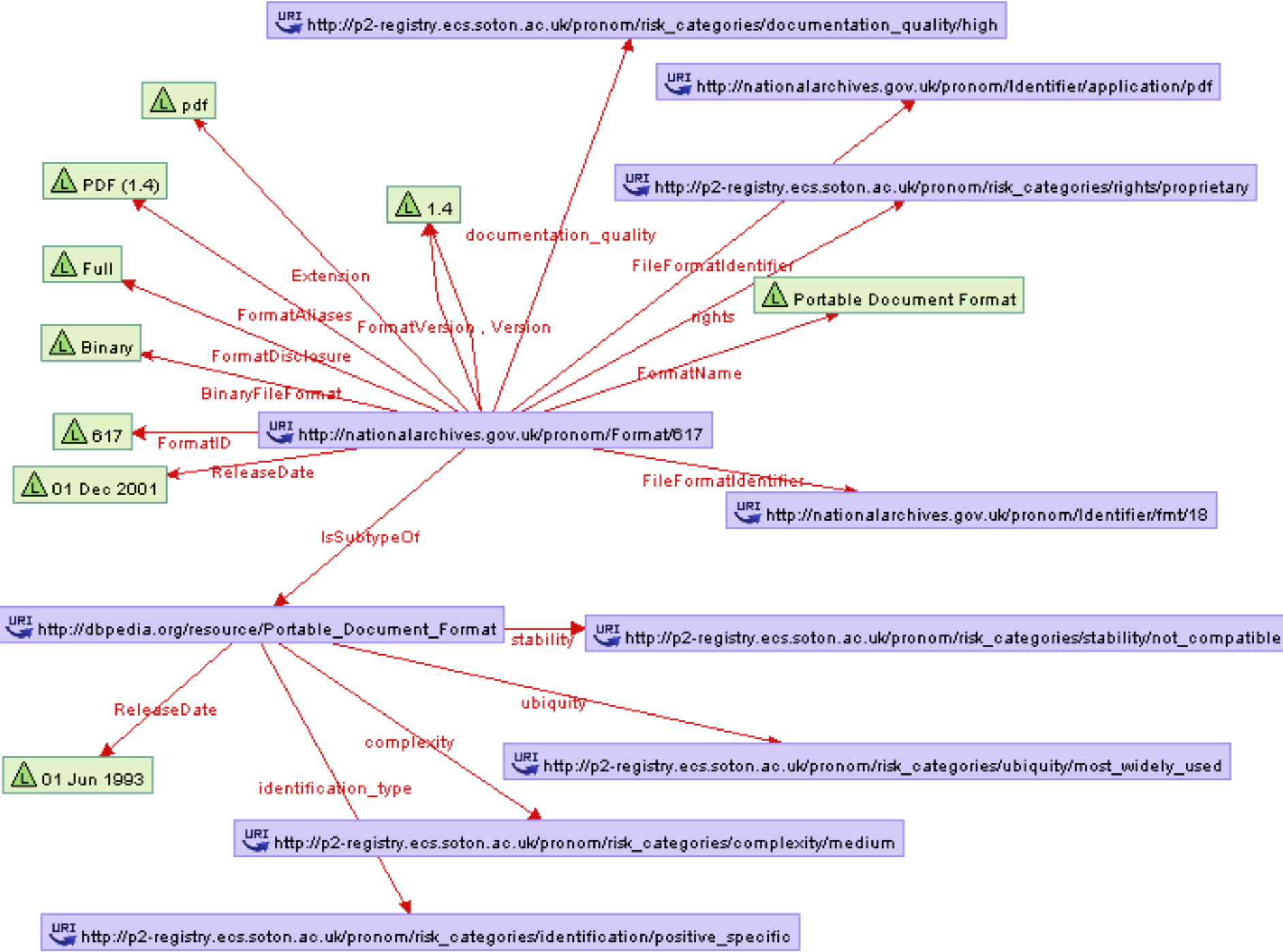
Category	Example	Data collection and measurement	Tools
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Outcome Format	Format is ISO standardised	Measurements of the output, Trusted external data sources	DROID, PRONOM, UDFR, P2

Some file format requirements

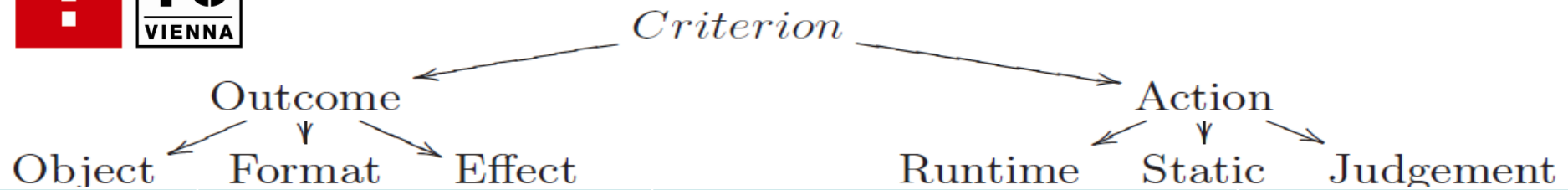
- Specifications available
 - Is an XML schema enough?
 - Syntacs **and semantics** needed
- Standardized (ISO, ANSI, ITEF, ...)
- Accepted and widely used (indicators?)
- Not covered by patent
- Free of compression
- Free of any cryptographical techniques

- Flexible and extensible?
- Anything else?

- PRONOM
 - Sparse data
- www.digitalpreservation.gov/formats
 - Incomplete
- Wikipedia
 - reliable?
- The web
 - unstructured
- P2: Combination of PRONOM with dbpedia
 - Linked Data
 - ~45.000 statements
 - Still far from complete

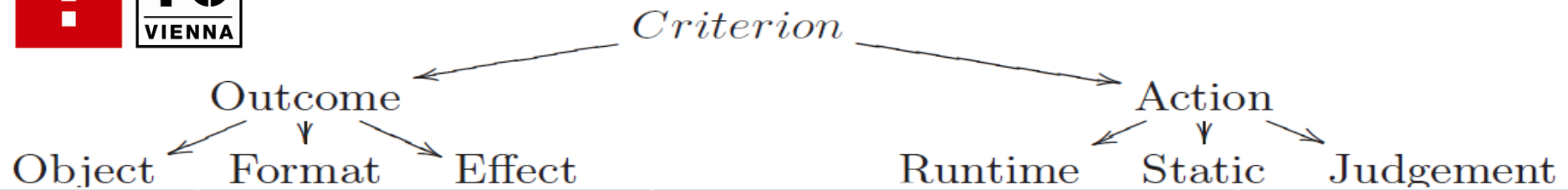


How to measure?



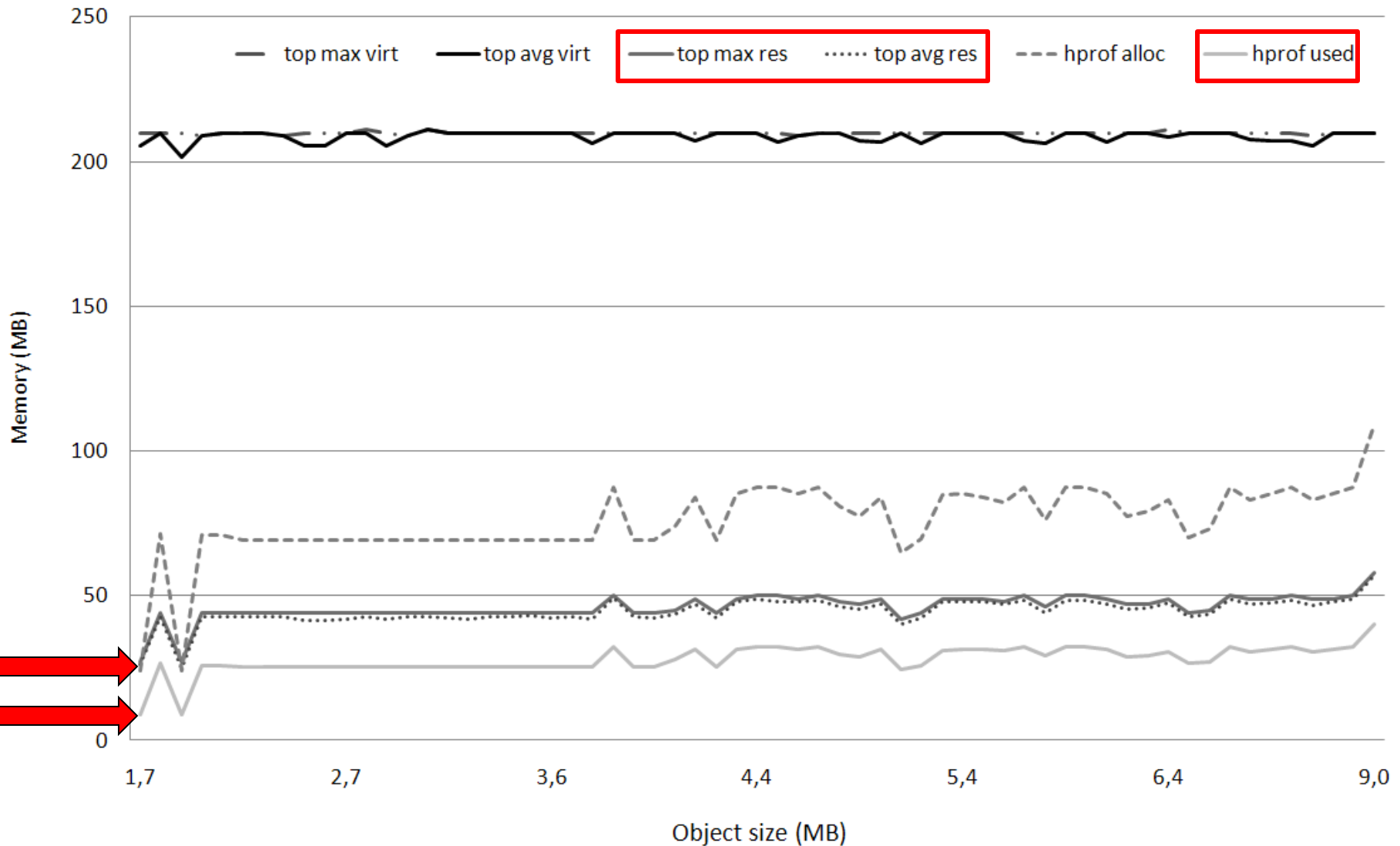
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Outcome effect	Annual bitstream preservation costs (€)	Measurements of the output, external data sources, models (LIFE)...	LIFE model

How to measure?

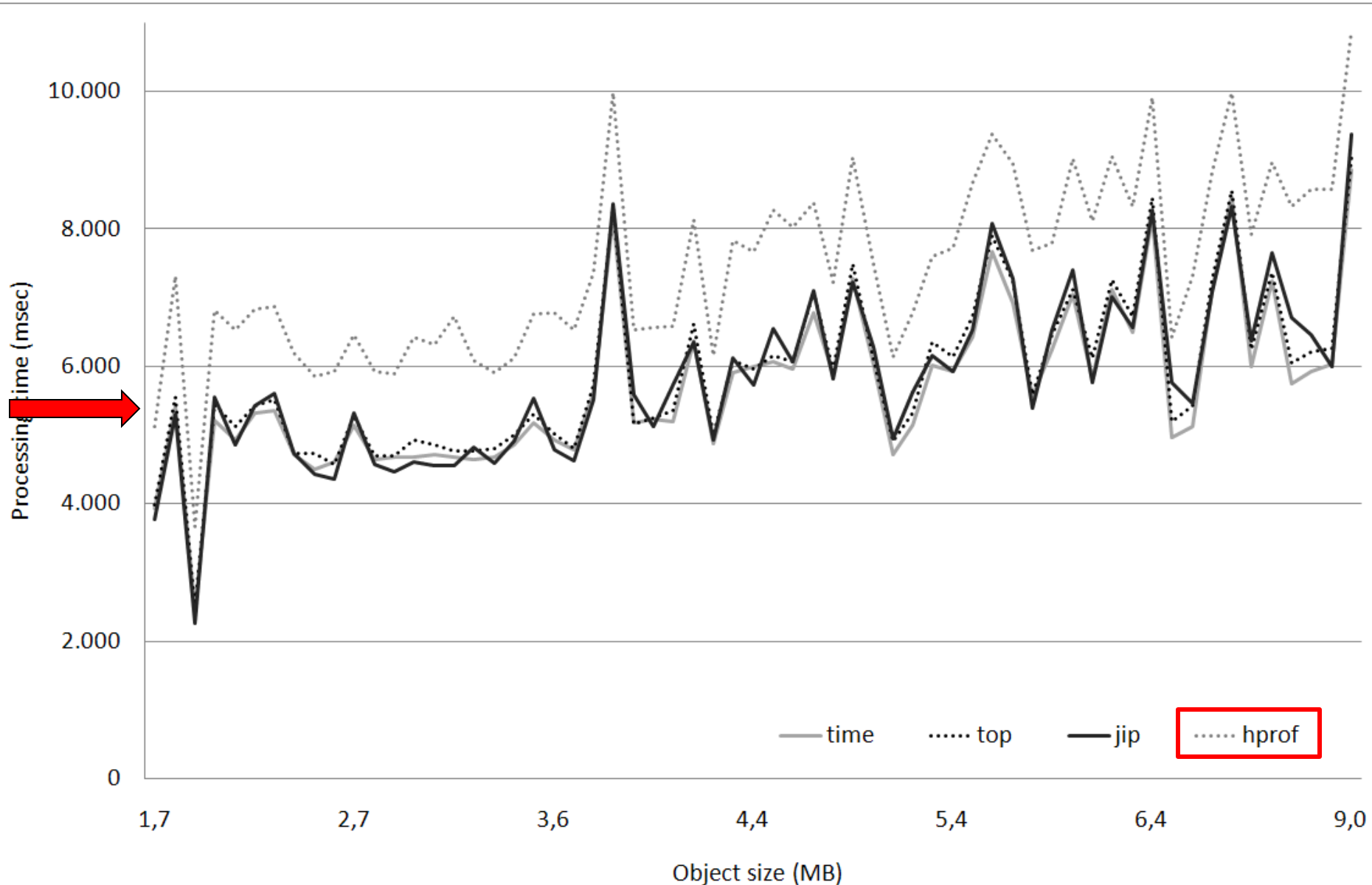


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Action runtime	Throughput (MB per millisecond), Memory usage	Measurements taken in controlled experimentation	MiniMEE

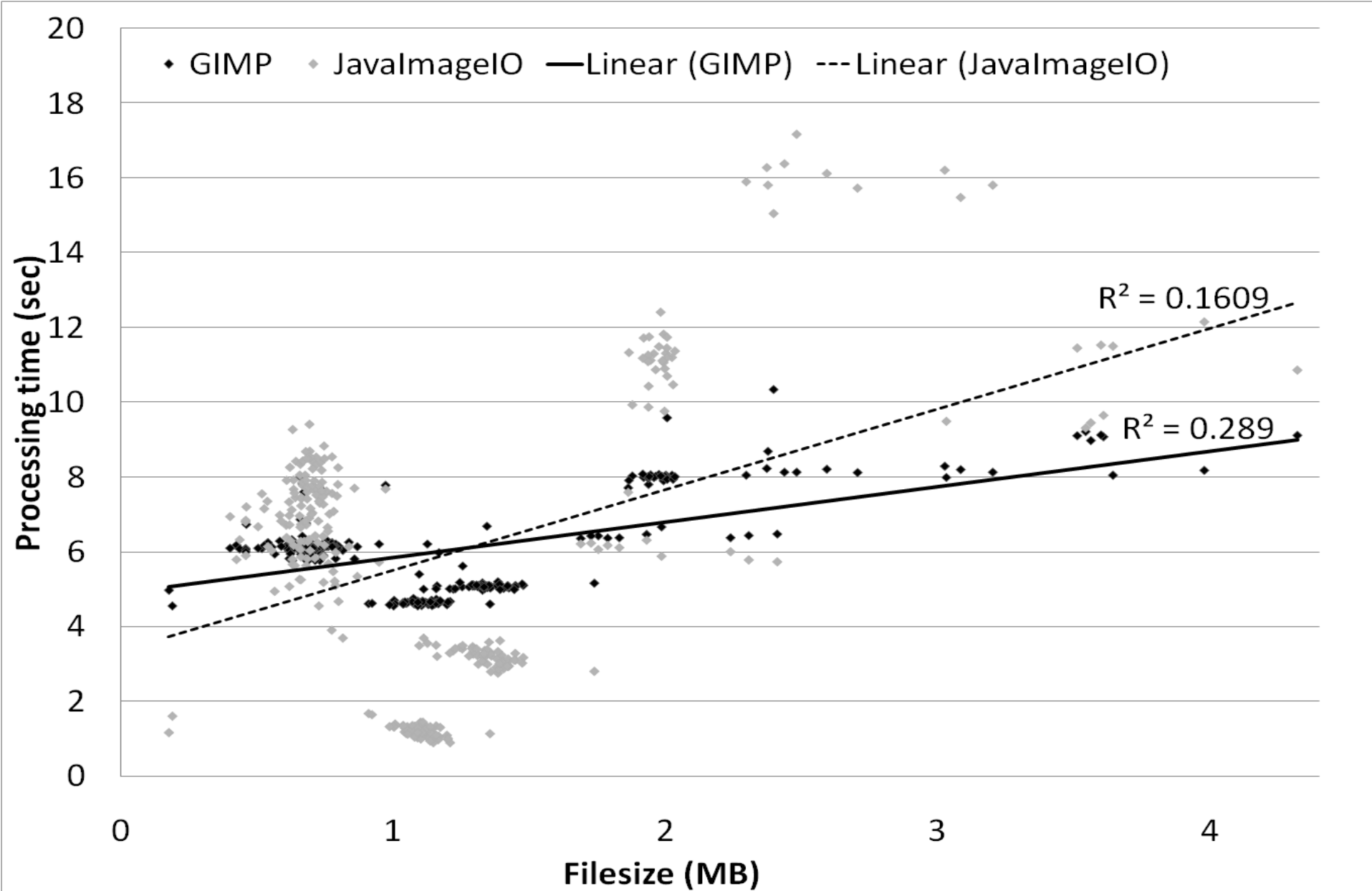
Profiling memory usage of Java tools



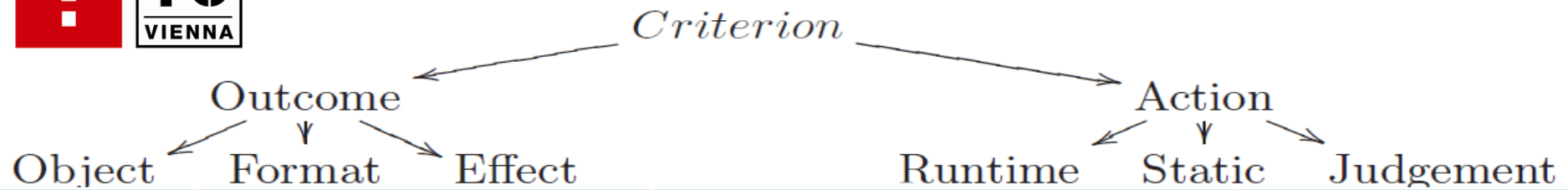
Profiling timing of Java tools



Comparing tool performance

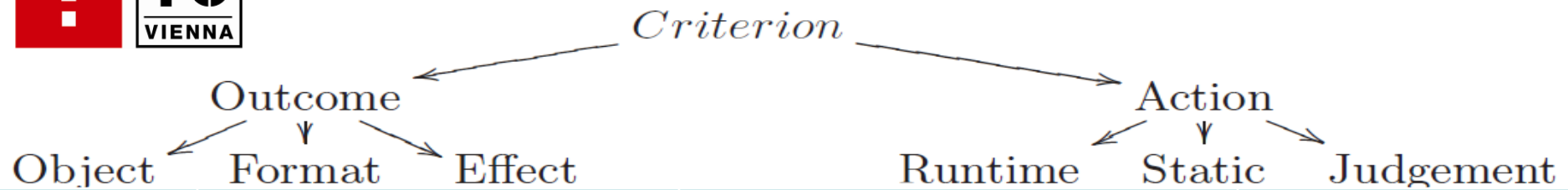


How to measure?



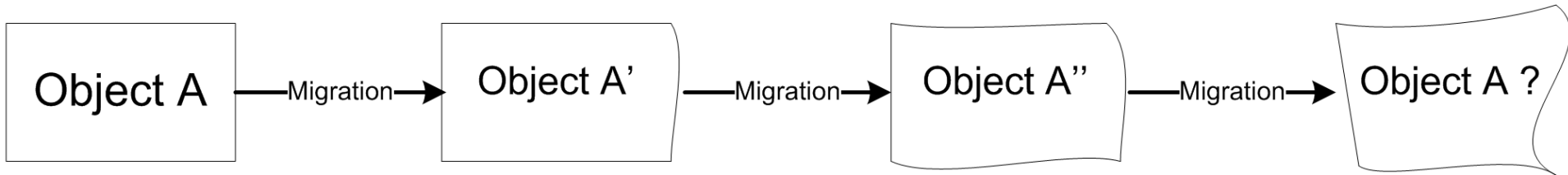
Category	Example	Data collection and measurement	Tools
Outcome Object	Image pixelwise identical Footnotes preserved	Measurements of output and input, comparison	FITS, JHove, ImageMagick...
Outcome Format	Format is ISO standardised	Measurements of the output, Trusted external data sources	DROID, PRONOM, UDFR, P2
Outcome effect	Annual bitstream preservation costs (€)	Measurements of the output, external data sources, models (LIFE)...	LIFE model
Action runtime	Throughput (MB per millisecond), Memory usage	Measurements taken in controlled experimentation	MiniMEE
Action static	License costs per CPU (€), Open Source License	Trusted external data sources, manual evaluation, sharing	UDFR, Pronom, P2, manual

How to measure?



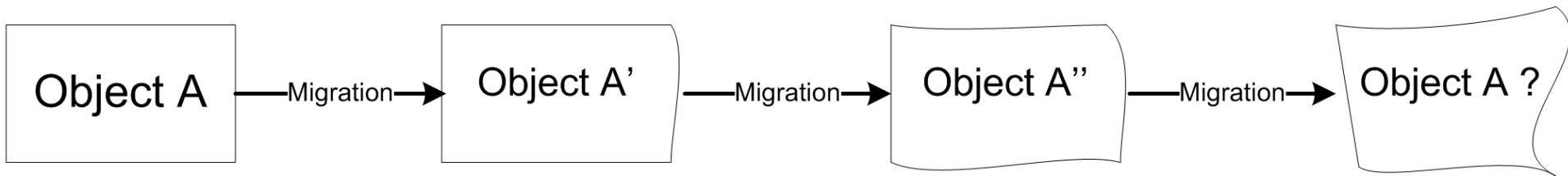
Category	Example	Data collection and measurement	Tools
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Action static	License costs per CPU (€), Open Source License	Trusted external data sources, manual evaluation, sharing	UDFR, P2, manual
Action judgement	Technical interoperability, configuration flexibility	Manual judgement, sharing	

- ❑ Essential object characteristics
 - ❑ Content
 - ❑ Appearance
 - ❑ Structure
 - ❑ Behaviour
 - ❑ Context

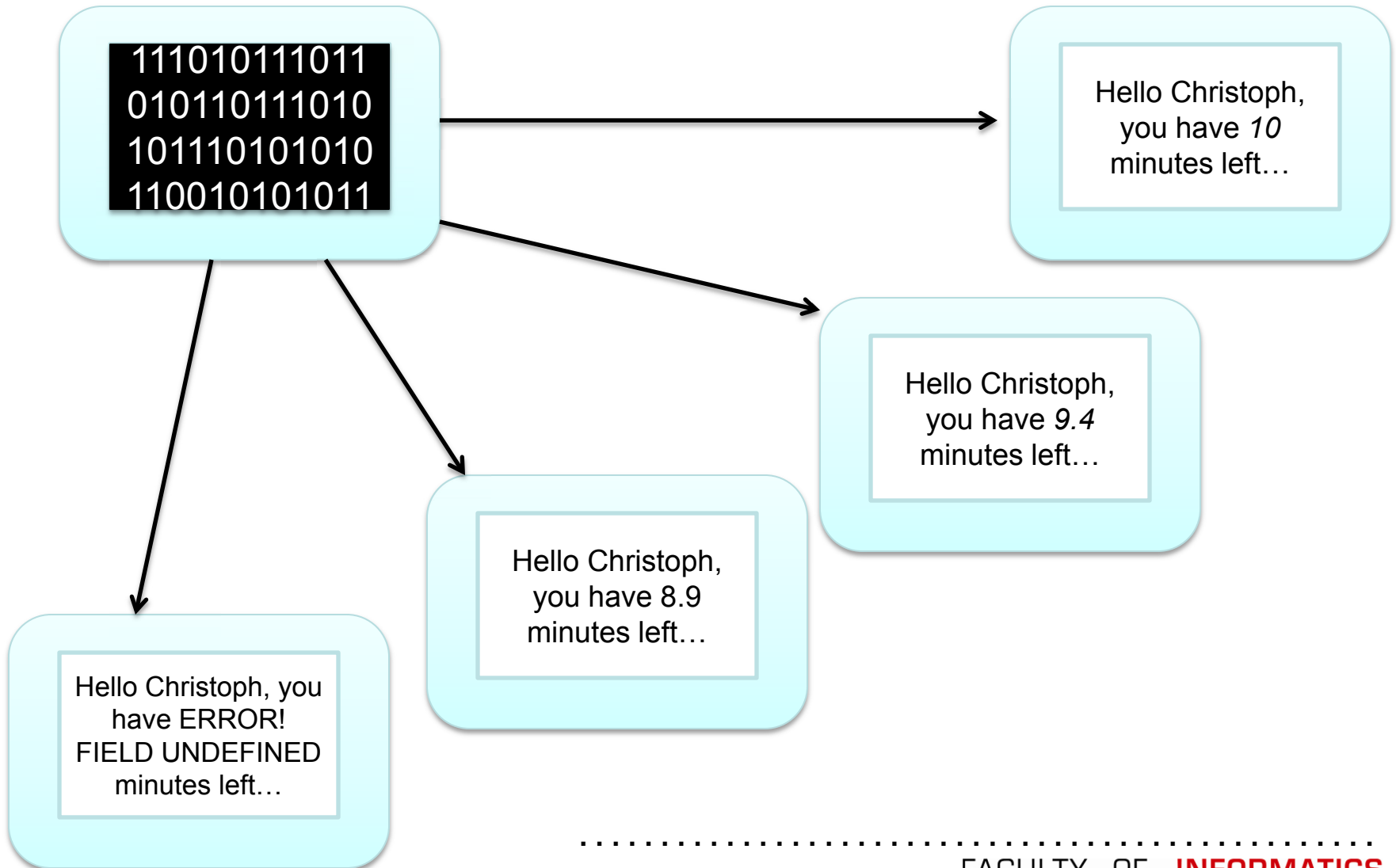


Validating a migrated image

- ❑ We run a TIFF file against a JPEG 2000 conversion tool and check:
 - ✓ Yes, it's in JPEG 2000 format
 - ✓ Yes, it's well-formed
 - ✓ Yes, it's valid
 - ✓ Yes, it still has the same dimensions
- ❑ But is it still the same image?



The black box problem



Five years later...

```
111010111011
010110111010
101110101010
110010101011
```

text.pdf

Hello Adam, you
have -21 minutes
left...

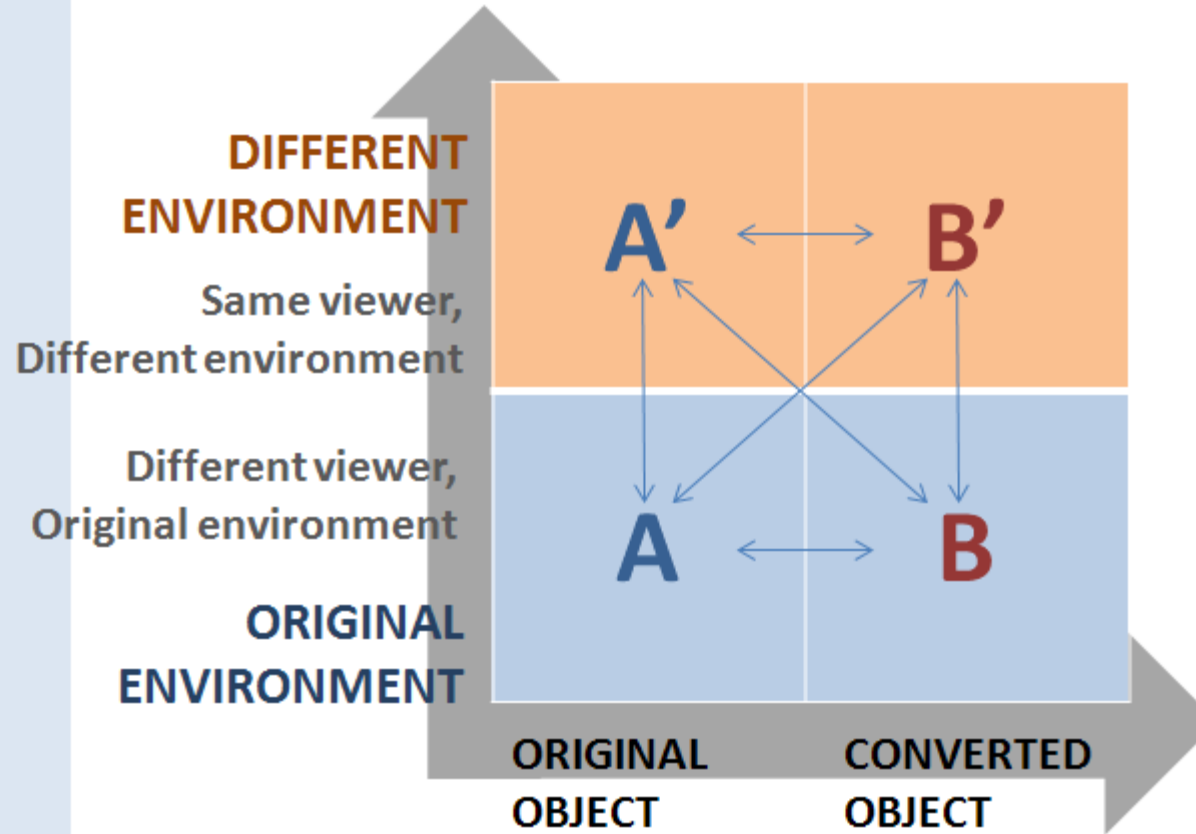
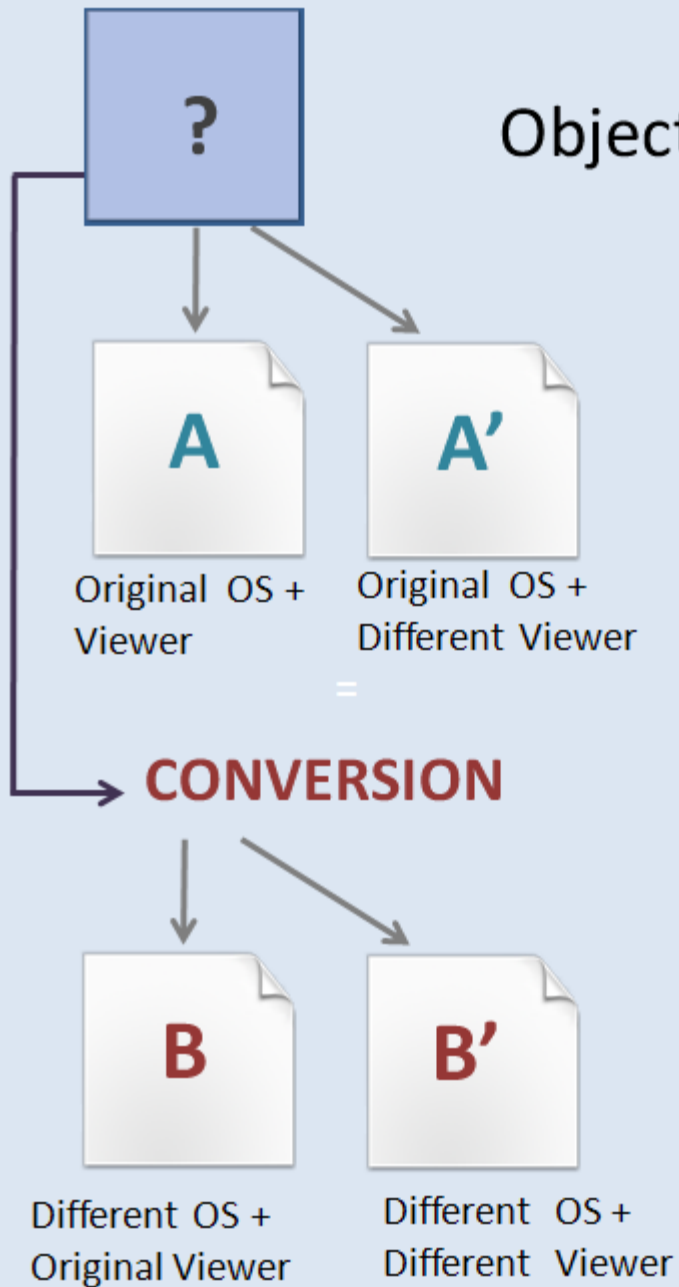
Hello Christoph, you
have 9.4 minutes
left...

text.docx

Hello ERROR! FIELD
UNDEFINED , you
have - 678345
minutes left...

Hello Christoph,
you have 10
minutes left

Objects, environments and dependencies

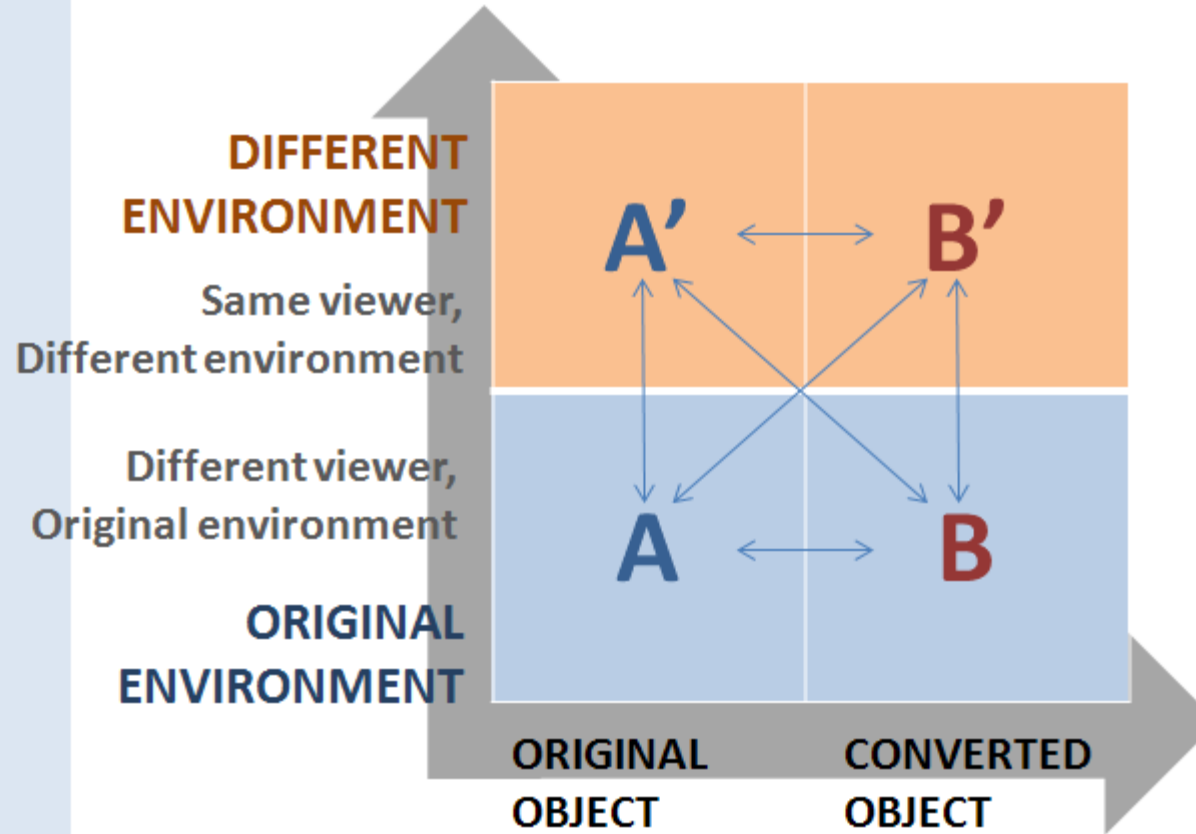
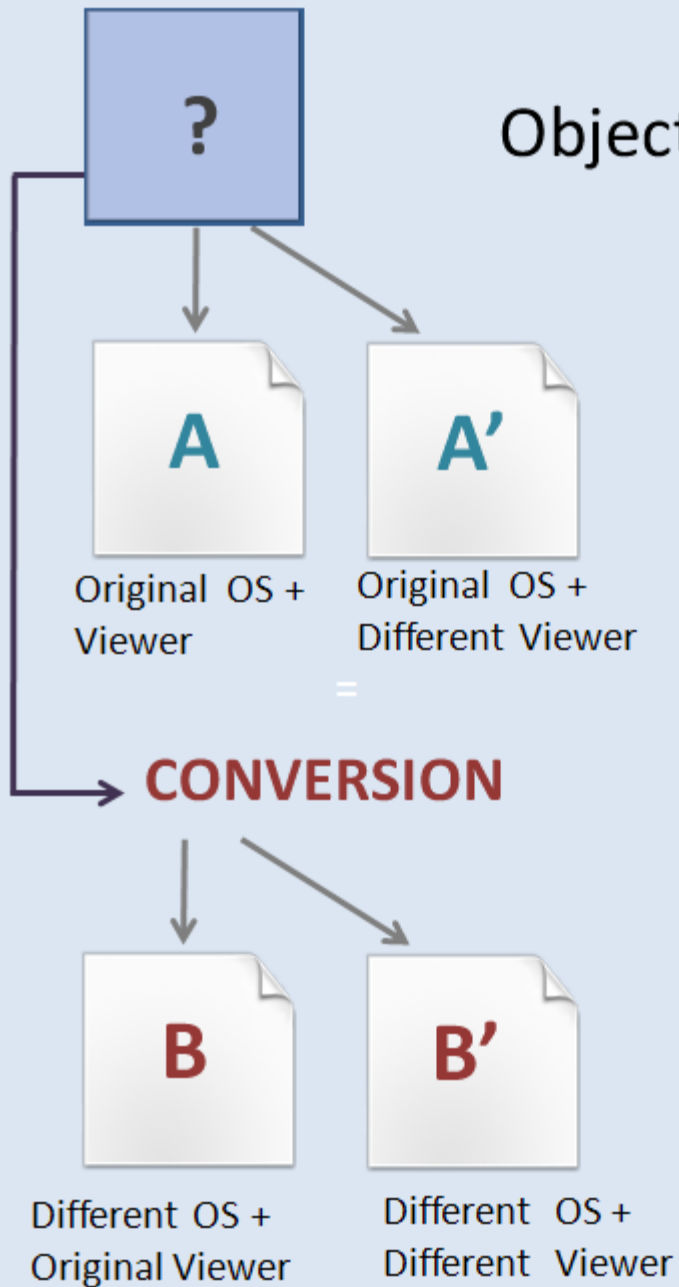


...networks of objects

Why do we need Digital Preservation?

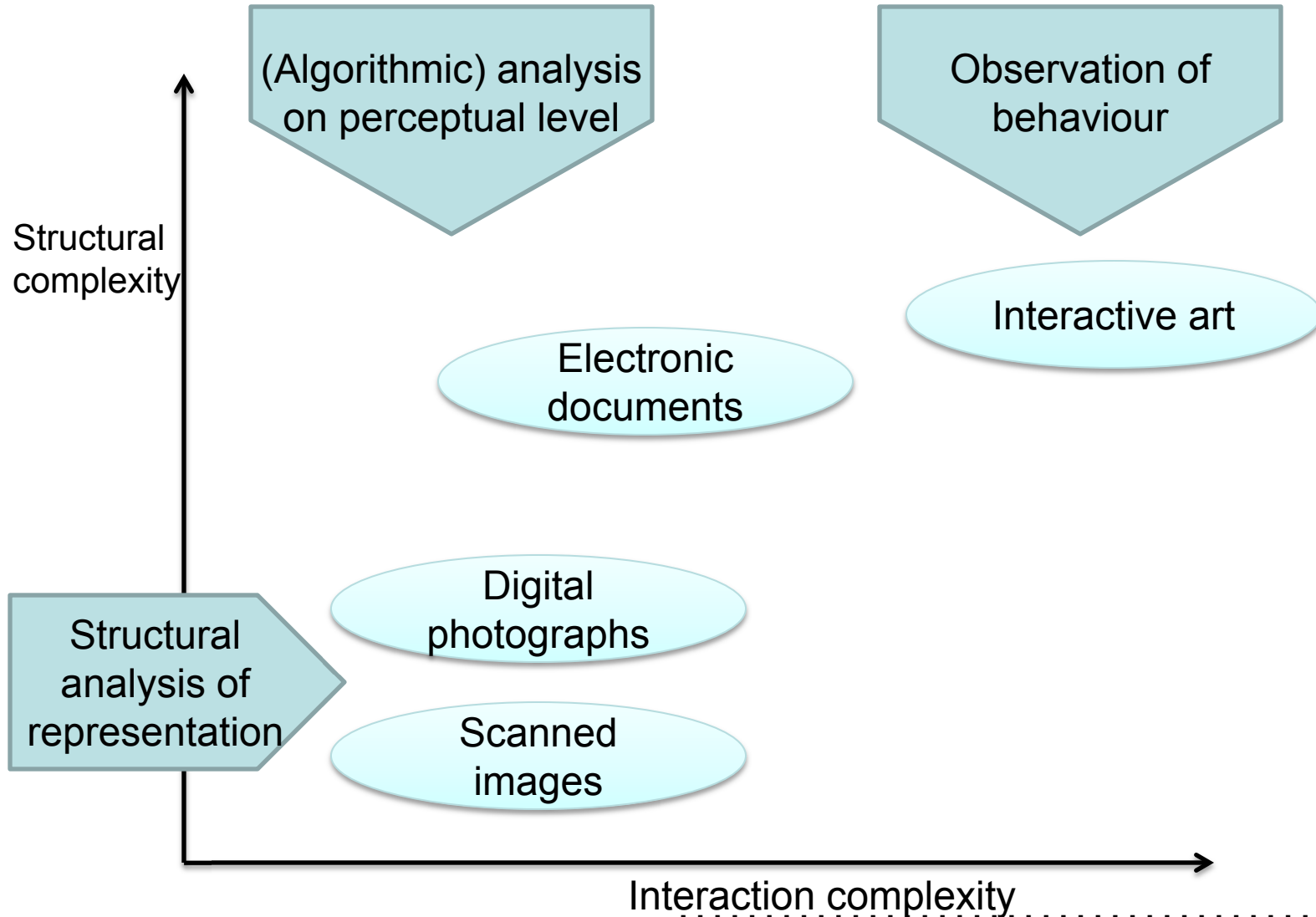
- ...
- ...
- ...
- ...
- ...
- programs won't
- ...
- ...
- ...

Objects, environments and dependencies



...networks of objects

Approaches to Quality Assurance

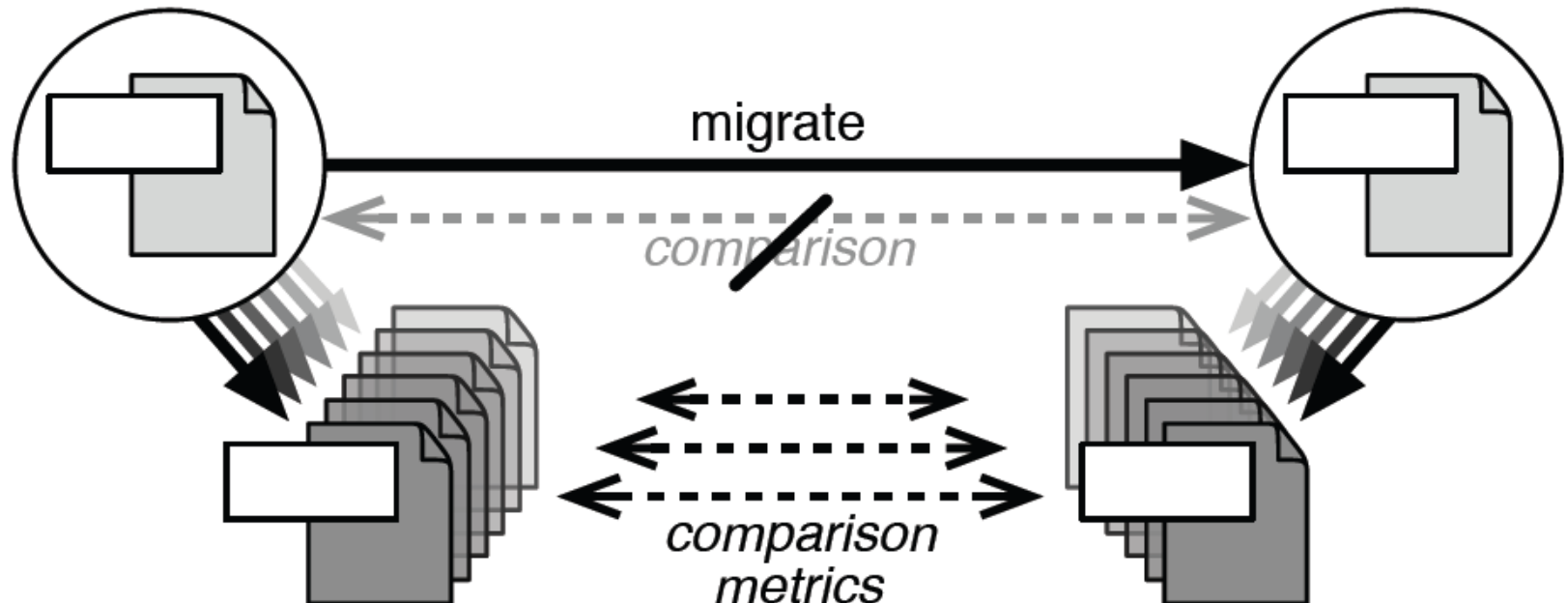


Validating a migrated image

- ❑ Dimensions, metadata.... easy: extract and compare
- ❑ Content... Not always easy
- ❑ ImageMagick *compare*: good for simple cases

Abbr.	Metric	Description
AE	Absolute Error	The number of different pixels (0 means identical images). This value can be thresholded to only count pixels that have a difference larger than a specified threshold.
PAE	Peak Absolute Error	The highest difference of any single pixel.
PSNR	Peak Signal to Noise Ratio	The ratio of mean square difference to the maximum mean square that can exist between any two images, expressed as a decibel value. The higher the PSNR, the closer the images are, with a maximum difference occurring at 1.
MAE	Mean Absolute Error	Average over all pixels
MSE	Mean Squared Error	Averaged squared error distance
RMSE	Root mean squared error	Identical to \sqrt{MSE} .

- Approaches to automated Quality Assurance
 - Characterization: Static analysis of representations
 - Semantics not fully contained in files
 - No homomorphic property mapping between (lots of) formats
 - Lack of ground truth
 - Perceptual-level analysis of standardised renderings





The file "CRW_2348.CRW" could not be opened.

Preview currently does not support this raw file format.

OK

Demosaiquing

White balance adjustment

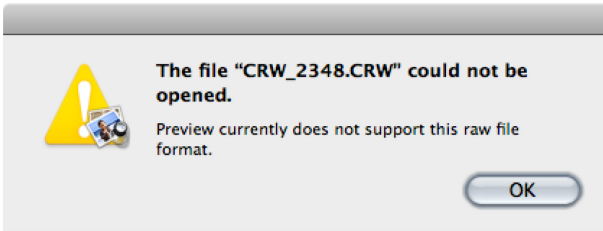
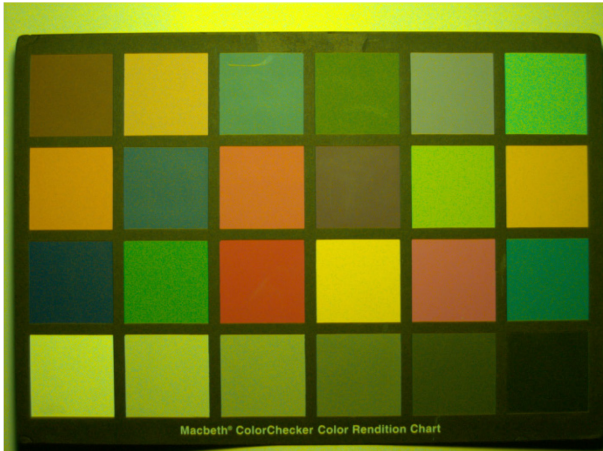
Colorimetric interpretation

Tone mapping

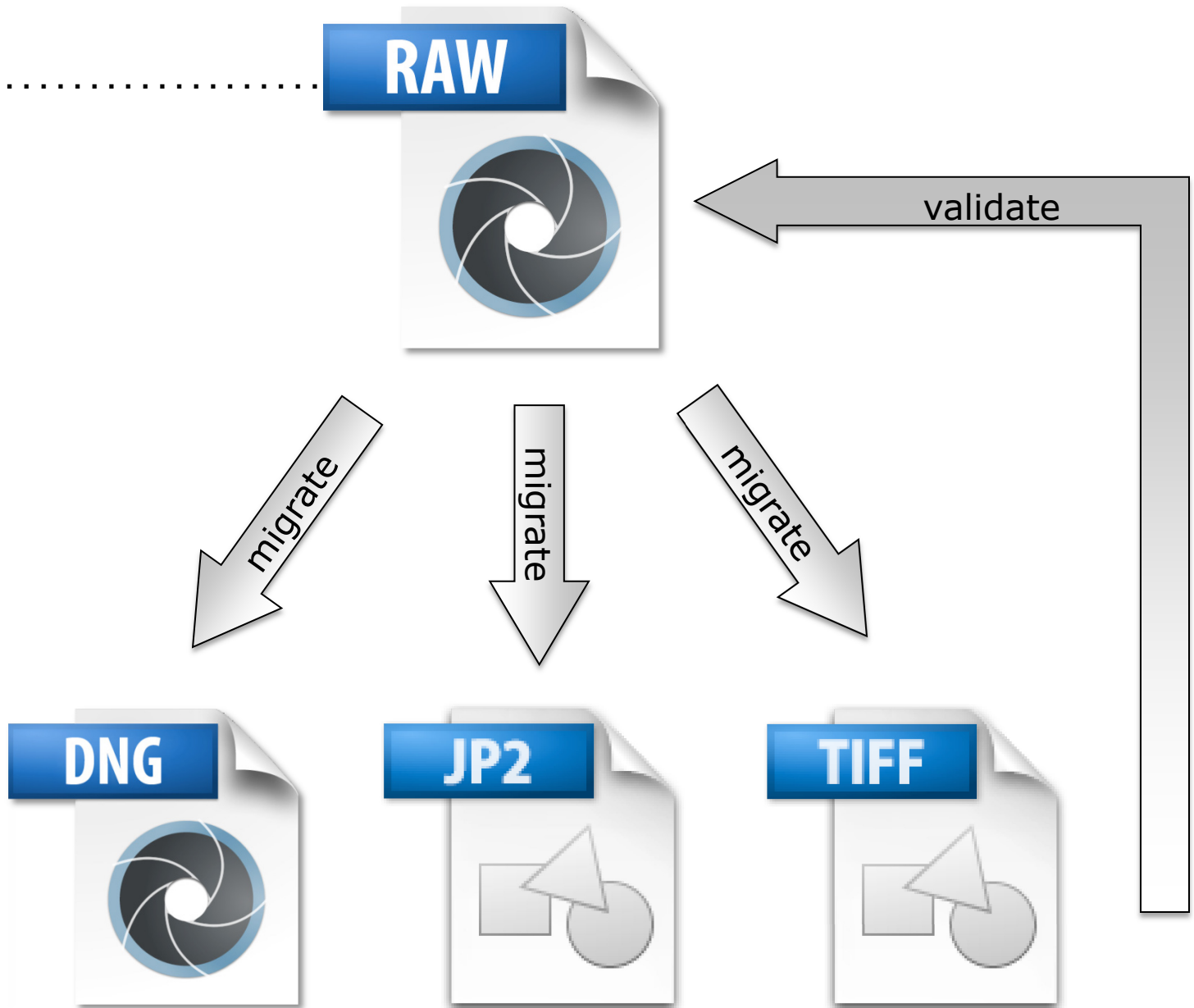
Image enhancements

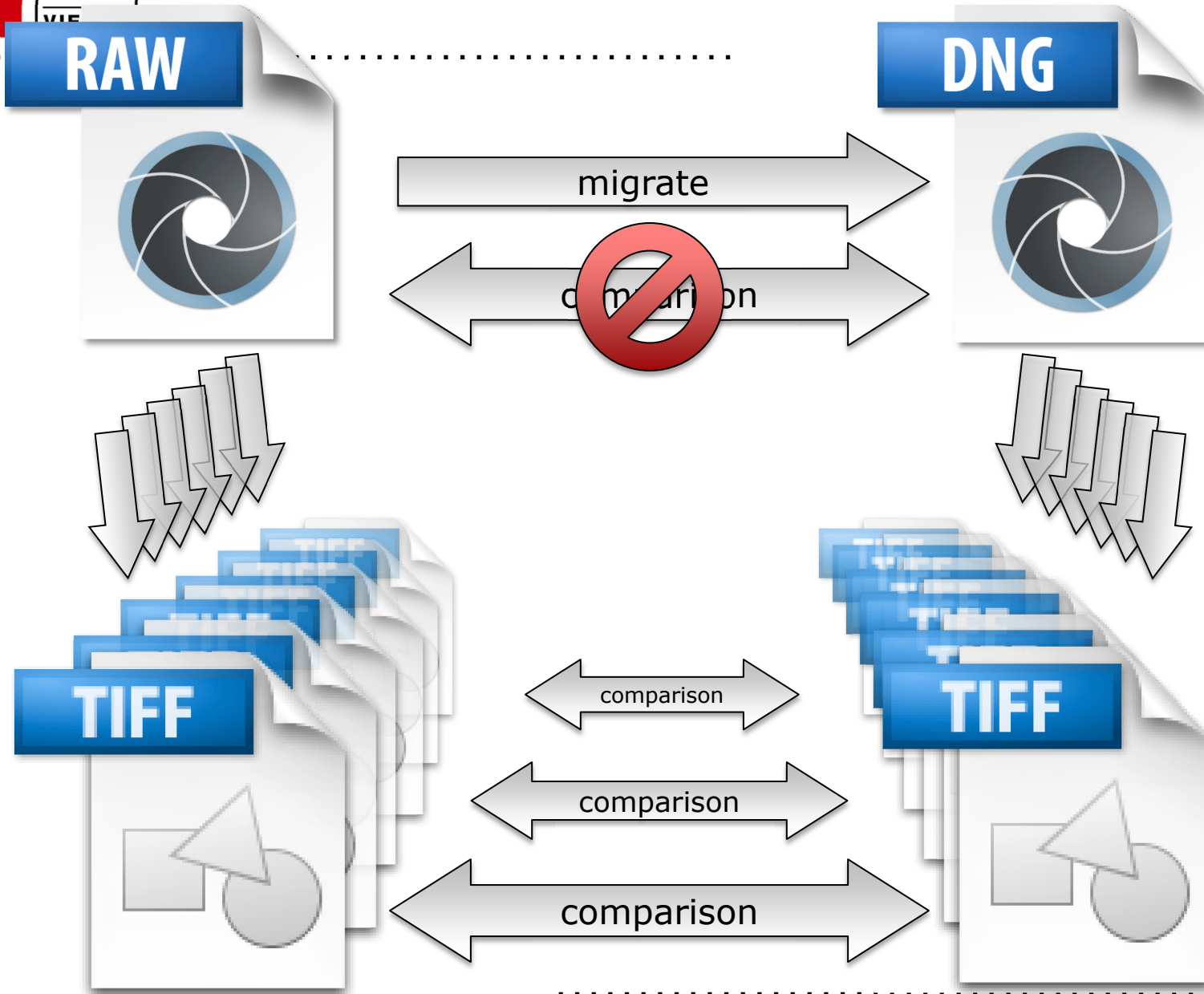


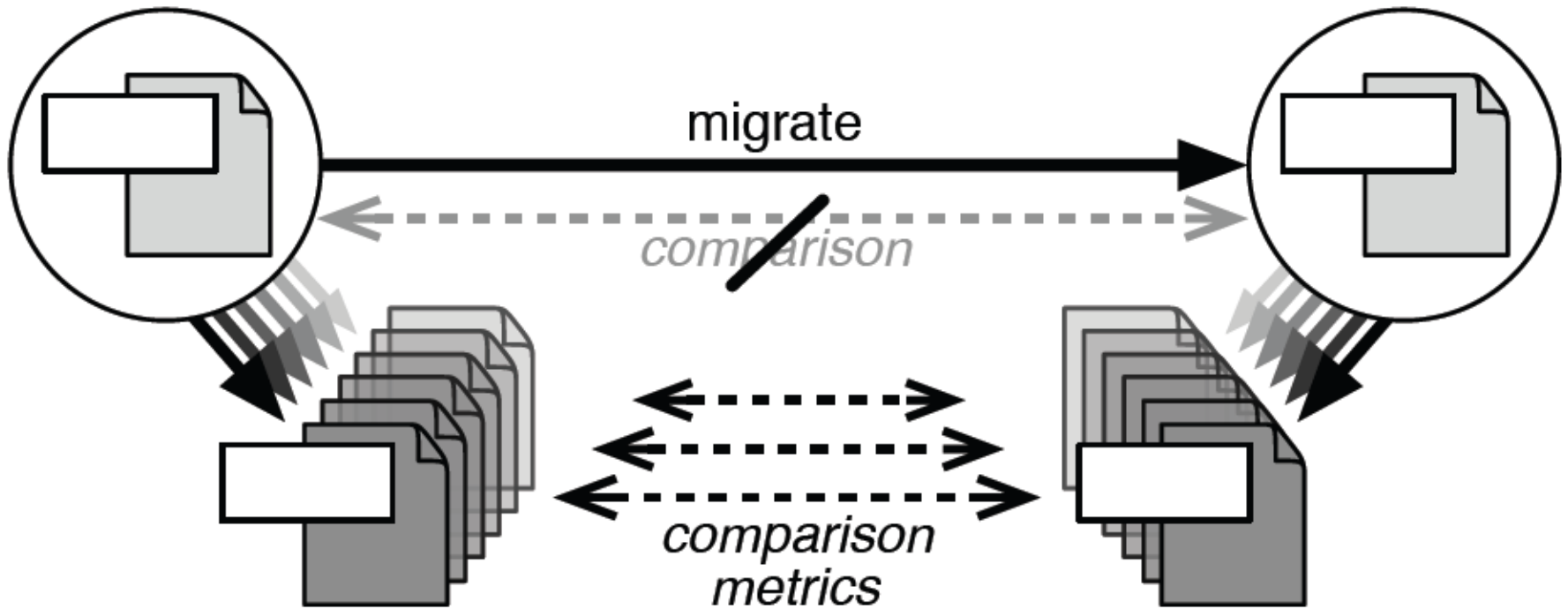




DRM



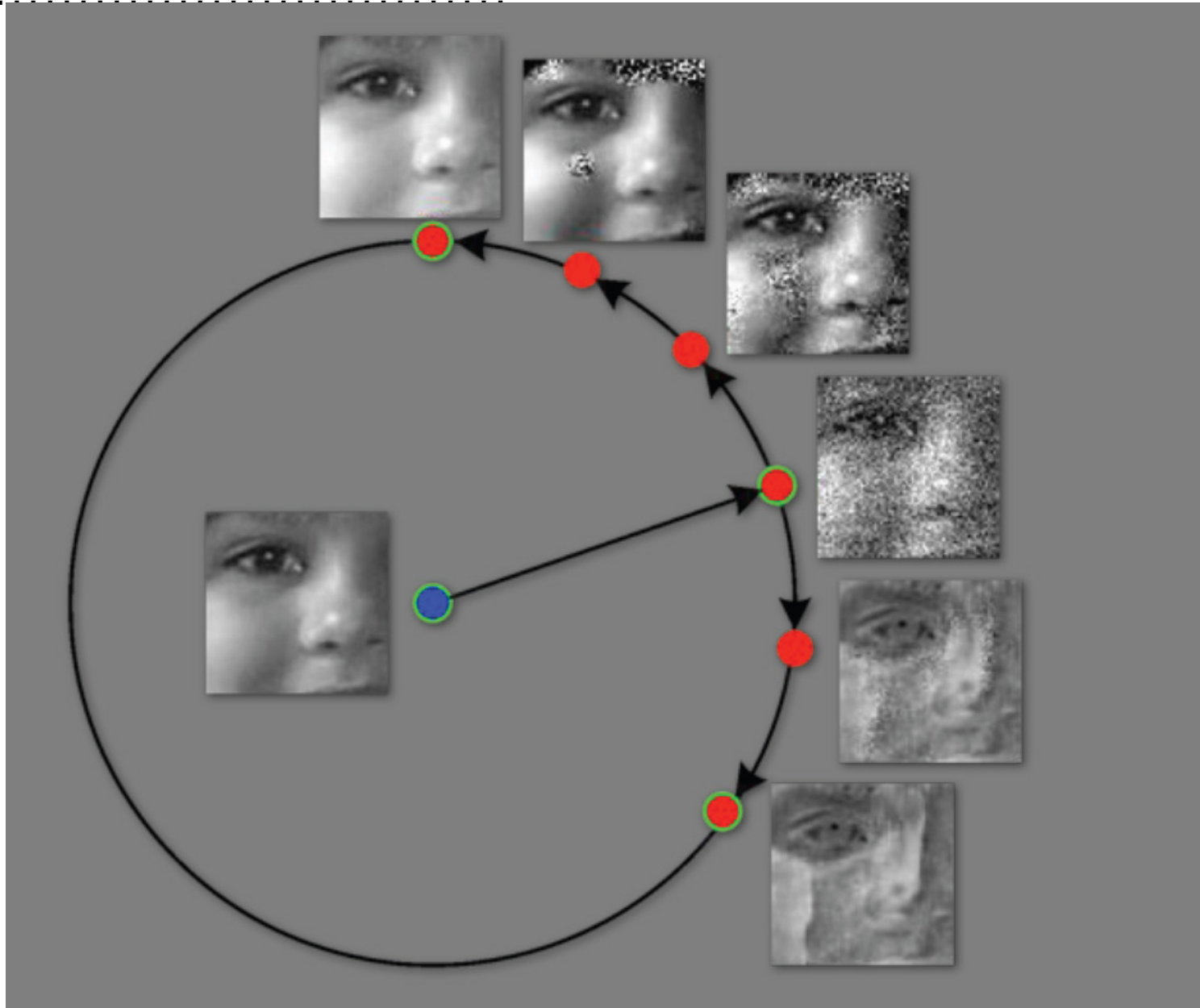




Distance metrics: How meaningful?

AE
PAE
RMSE
...
SSIM

Anything but
"0" is a
problematic
result



- From strategy and policies to operations
- A simple, methodologically sound model to specify and document requirements
- Repeatable and documented evaluation for informed and accountable decisions
- Generic workflow that can be integrated in different institutional settings
- **Plato:**
Tool support to perform solid, well-documented analysis
- Provides basic preservation plan

<http://www.ifs.tuwien.ac.at/dp/plato>

Planning Challenges

- Creating a plan is effort-intensive
- Sharing experience is difficult
- Monitoring changes is manual
- Integrating context, strategies and operations is difficult

- Creating a plan is effort-intensive
 - Increase efficiency of planning
- Sharing experience is difficult
 - Increase standardisation and reusability
- Monitoring changes is manual
 - Introduce automation
- Integrating context, strategies and operations is difficult
 - Systematic governance structures
 - Manage policies
 - Integrate systems

- Knowledge base
 - Entities and their properties
 - Measures of properties over time
 - Triggers define conditions and events
- Flexible and extensible
 - A well-defined, flexible data model
 - Adaptors for different information sources
- Monitoring Capabilities
 - Internal Monitoring
 - External Monitoring
 - Monitor compliance, risks and opportunities

Compliance, risk and opportunities

PLAN	C1	C2	C3	C4	
<i>Automated?</i>	Yes	Yes	No	No	
Alternative 1	✓	✓	✗	✓	✓
Alternative 2	⊘	✗	✓	✗	
Alternative 3	✓	✓	✓	⊘	
Alternative 4	✗	✗	✗	✗	

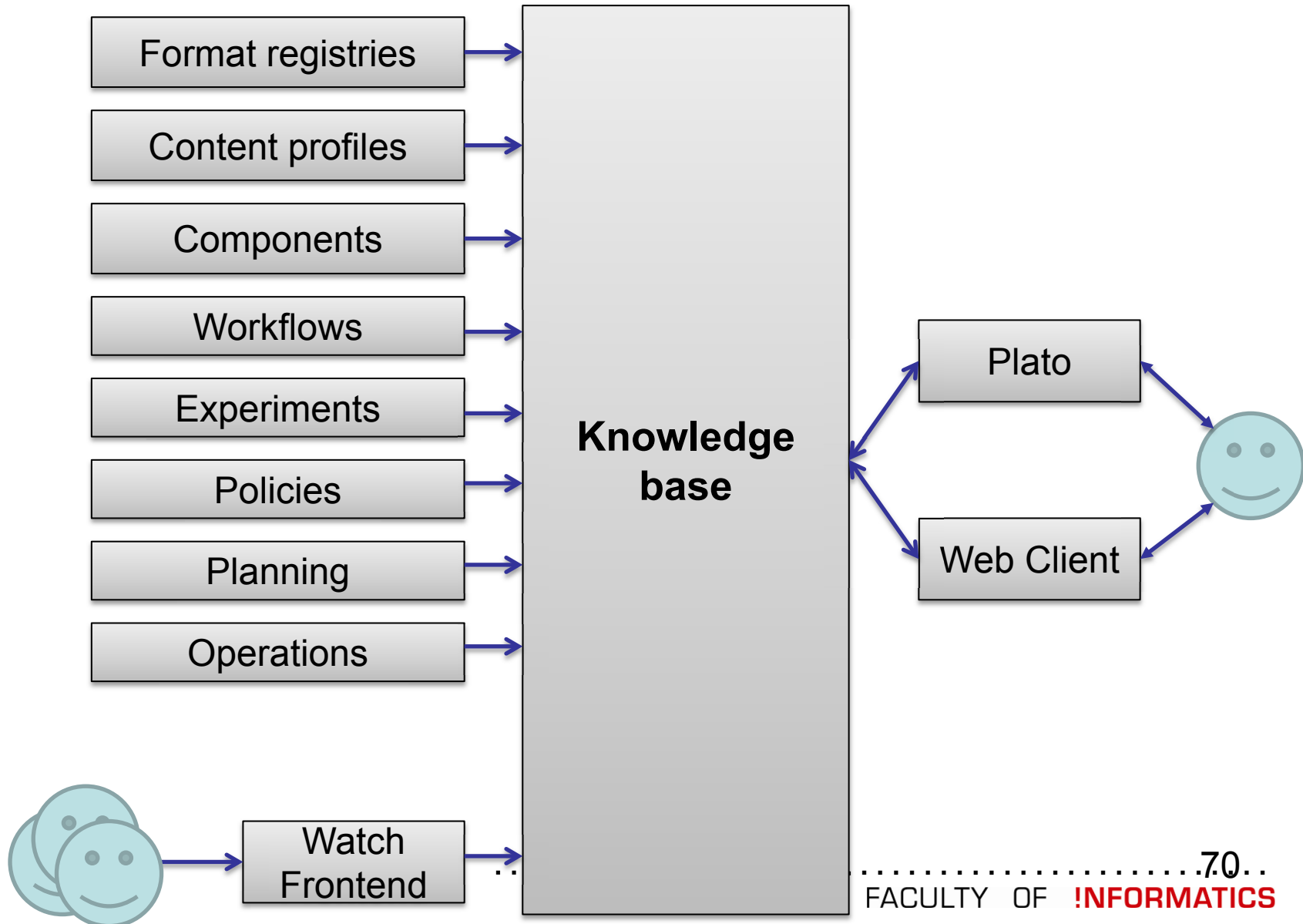
Compliance of operations to deployed plan (SLAs)

Opportunities for operations (new action tool)

Risks to operations (errors uncovered in QA tool)

Opportunities for operations (new QA tool)

- Planning needs to generate Service Level Agreements (SLAs) and monitoring conditions

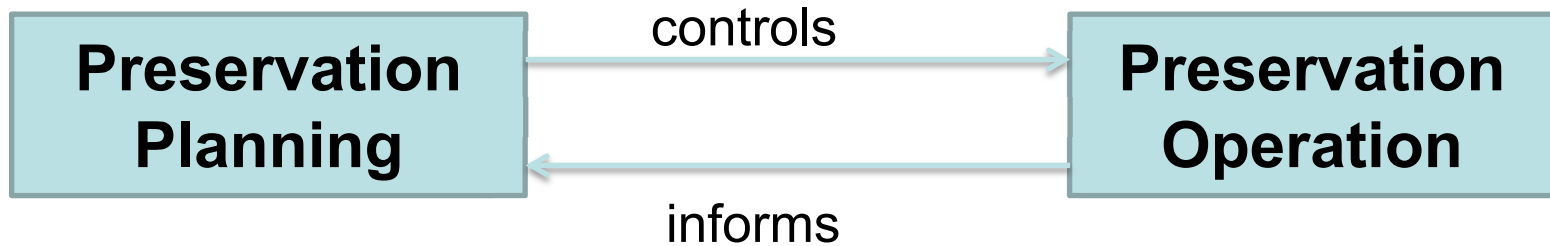


Core Preservation Capabilities



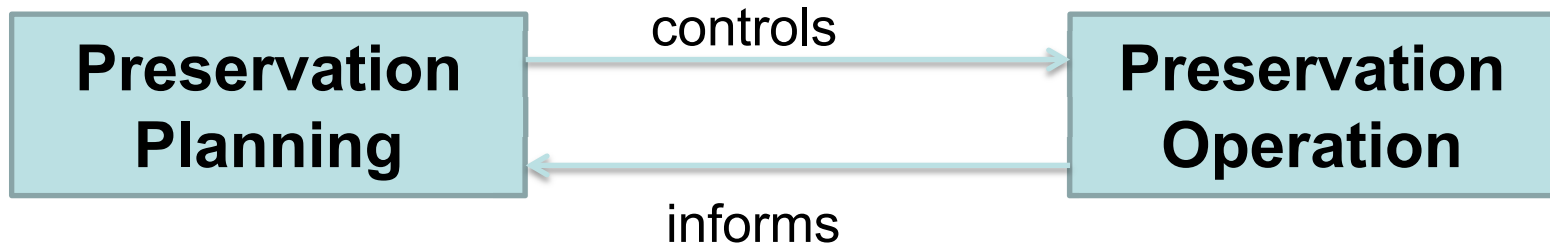
Preservation Planning	Preservation Operation
Monitor, steer and control the preservation operation of content	Control the deployment and execution of preservation plans.

Core Preservation Capabilities



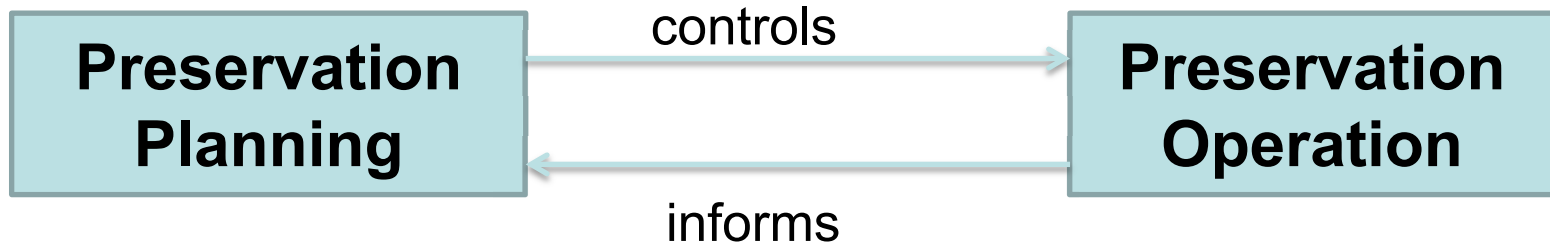
Preservation Planning	Preservation Operation
	Run operations and report on them
	<ul style="list-style-type: none">•Analyze content•Execute preservation actions•Ensure adequate provenance trail•Handle preservation metadata•Conduct Quality Assurance•Provide reports and statistics

Core Preservation Capabilities



Preservation Planning	Preservation Operation
Monitor and control operations	Run operations and report on them
<ul style="list-style-type: none"> •Influencers and Decision making •Options diagnosis •Specification and delivery •Monitoring 	<ul style="list-style-type: none"> •Analyze content •Execute preservation actions •Ensure adequate provenance trail •Handle preservation metadata •Conduct Quality Assurance •Provide reports and statistics

Core Preservation Capabilities



Preservation Planning	Preservation Operation
Monitor and control operations	Run operations and report on them
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<p><i>“Migrate this set of images (in TIFF-5) to JP2 using ImageMagick 6.3 with parameters a,b,c”</i></p>	<ul style="list-style-type: none"> •Analyze original •Migrate, analyse output •Conduct quality assurance •Provenance, metadata, Reporting

