COMPUTATIONWORLD 2021

On the Use of Code Generation Patterns for the Creation of Evolvable Documents and Runtime Artifacts

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APRIL, 2021

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Presenter

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  - Electronics engineer, PhD Computer vision (1993)
  - Full professor University of Antwerp
    - https://www.uantwerpen.be/en/staff/herwig-mannaert/
  - Research on evolvable software engineering
  - Co-author Normalized Systems Theory (NST)
    - Theory to design evolvable modular structures
  - Co-founder NSX bv
    - Making code generators and software based on NST
  - Co-founder Cast4All NV
    - Making software for energy monitoring, e.g., solar installations
  - Husband and father of 4 children

Overview

- Modular and Evolvable Document Creation
- Expansion of Evolvable Modular Structures
- Exploring Runtime Expansion of Artifacts
- Conclusion

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- Modular and Evolvable Document Creation
  - Document Creation and Single Sourcing
  - Modular and Parametrized Document Generation
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Document Creation and Single Sourcing

- An example of modularity in document management and creation is Component Content Management (CCM):
  - Separation of content and layout
  - Granularity based on smallest unit of information
- Related is the fundamental concept of Single Sourcing:
  - Make content reusable by separating it from format
  - Write content in stand-alone modules
  - Modules are linked to generate documents
- Document creation distinguishes:
  - Repurposing
  - Reassembly

Modular and Parametrized Document Creation

- CCM highly reminiscent of similar concepts in software codebases
  - Separate concerns in singular source files
  - Assemble source modules in quest to reuse
  - Evolvability hampered by rippling of changes
  - Successive versions in time and variations in content
- Concurrent variants highly reminiscent of software code generation
  - Parameter-based or model-based instantiation
    - Procedures and descriptions of various technical installation manuals
    - Many variants of simple administrative documents and letters

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- Modular and Evolvable Document Creation
- Expansion of Evolvable Modular Structures
  - Normalized Systems Theory and Evolvable Structures
  - Meta-Circular Code Generation or Artifact Expansion
- Exploring Runtime Expansion of Artifacts
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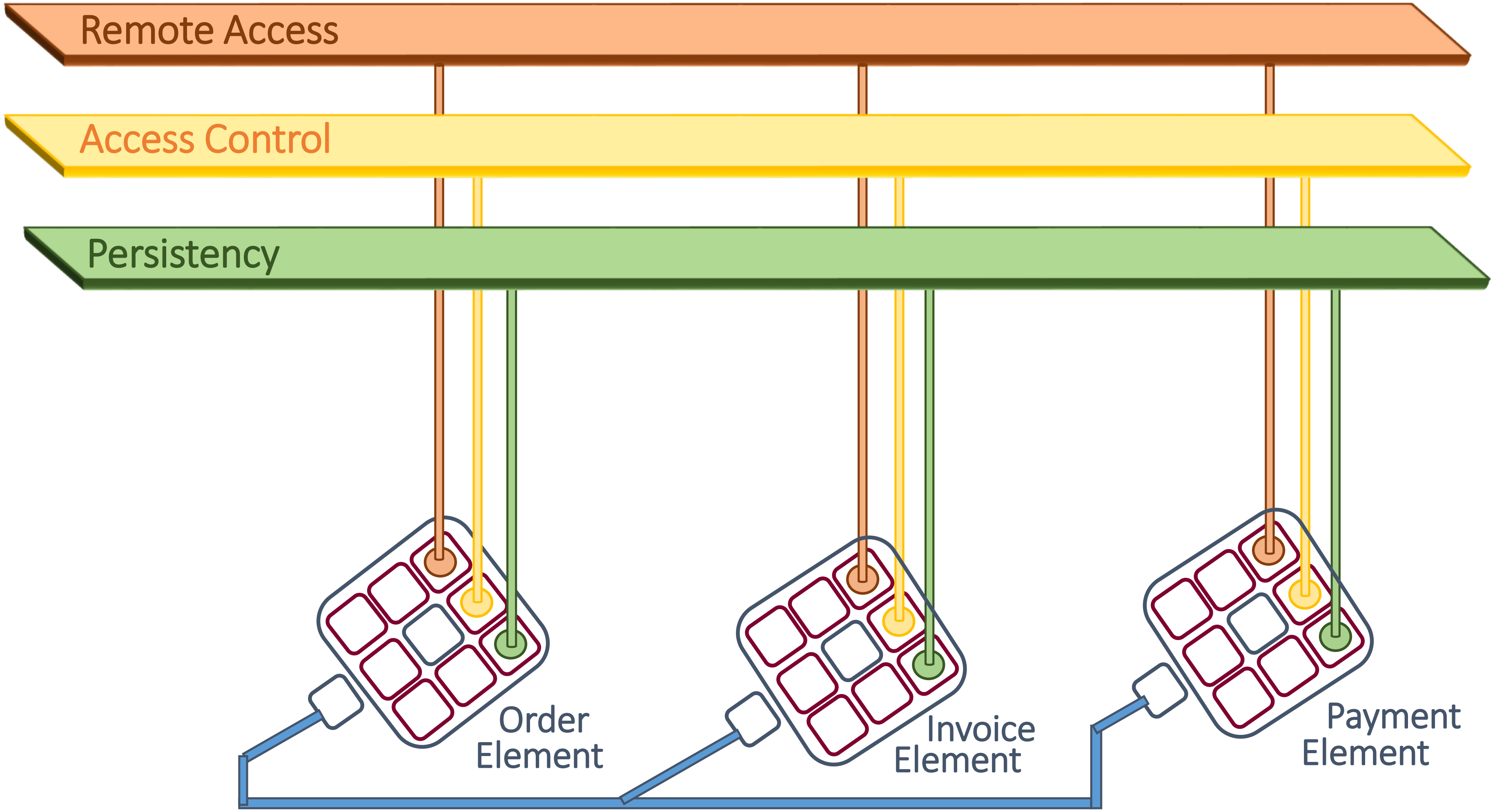
Normalized Systems Theory and Evolvable Structures

- In order to avoid dynamic instabilities in the software design cycle, the *rippling of changes needs to be depleted or damped: a = 0*
- As these ripples create *combinations of multiple changes* for every functional change, we call these instabilities ***combinatorial effects***
- Demanding systems theoretic stability for the software transformation, leads to the derivation of ***four principles*** in line with existing heuristics
- Adhering to these principles avoids dynamic instabilities, meaning that these *principles are necessary, not sufficient for systems stability*
    - *Separation of Concerns*
    - *Action Version Transparency*
    - *Data Version Transparency*
    - *Separation of States*

Applying Design Theorems, Software Elements Emerge



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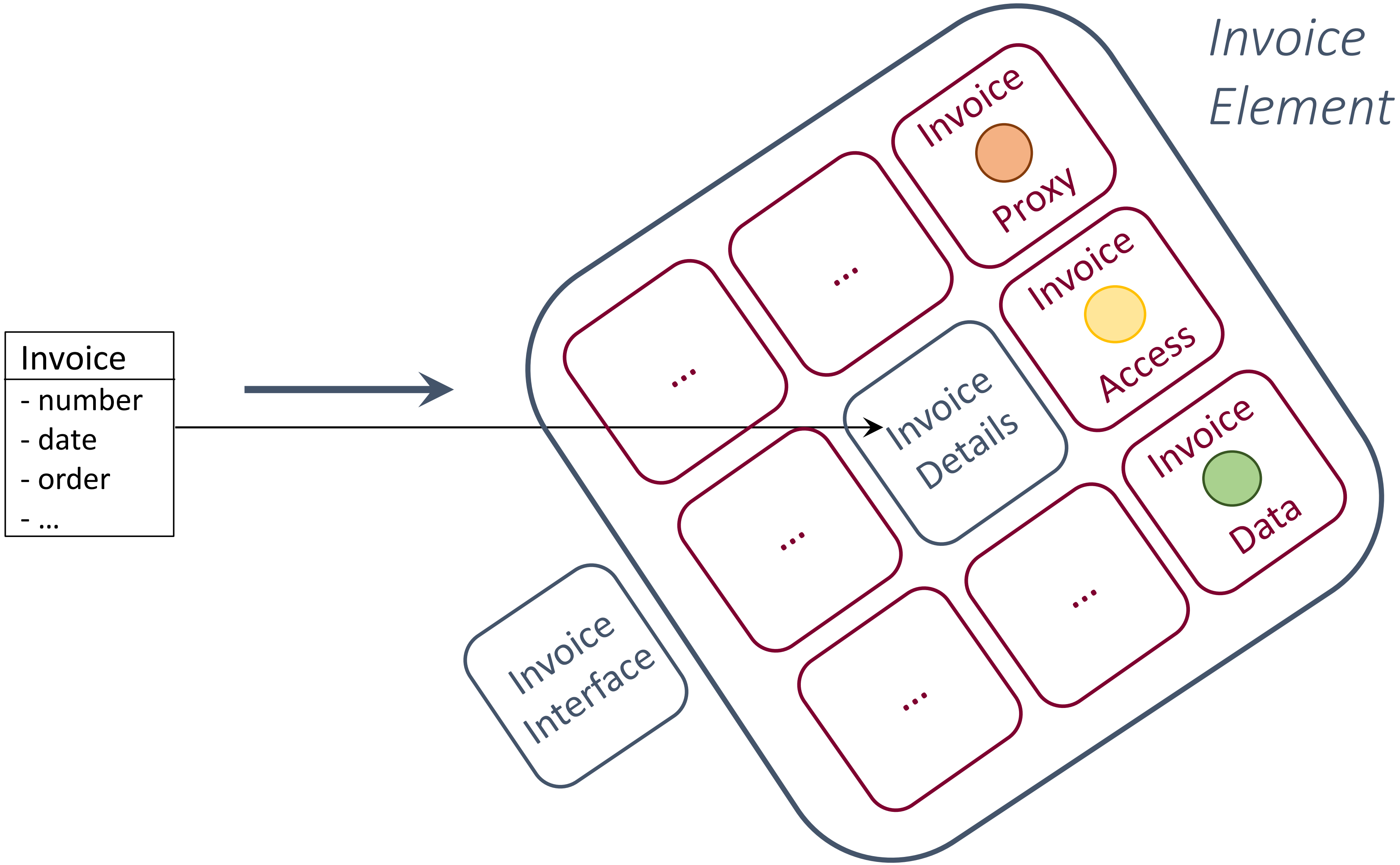
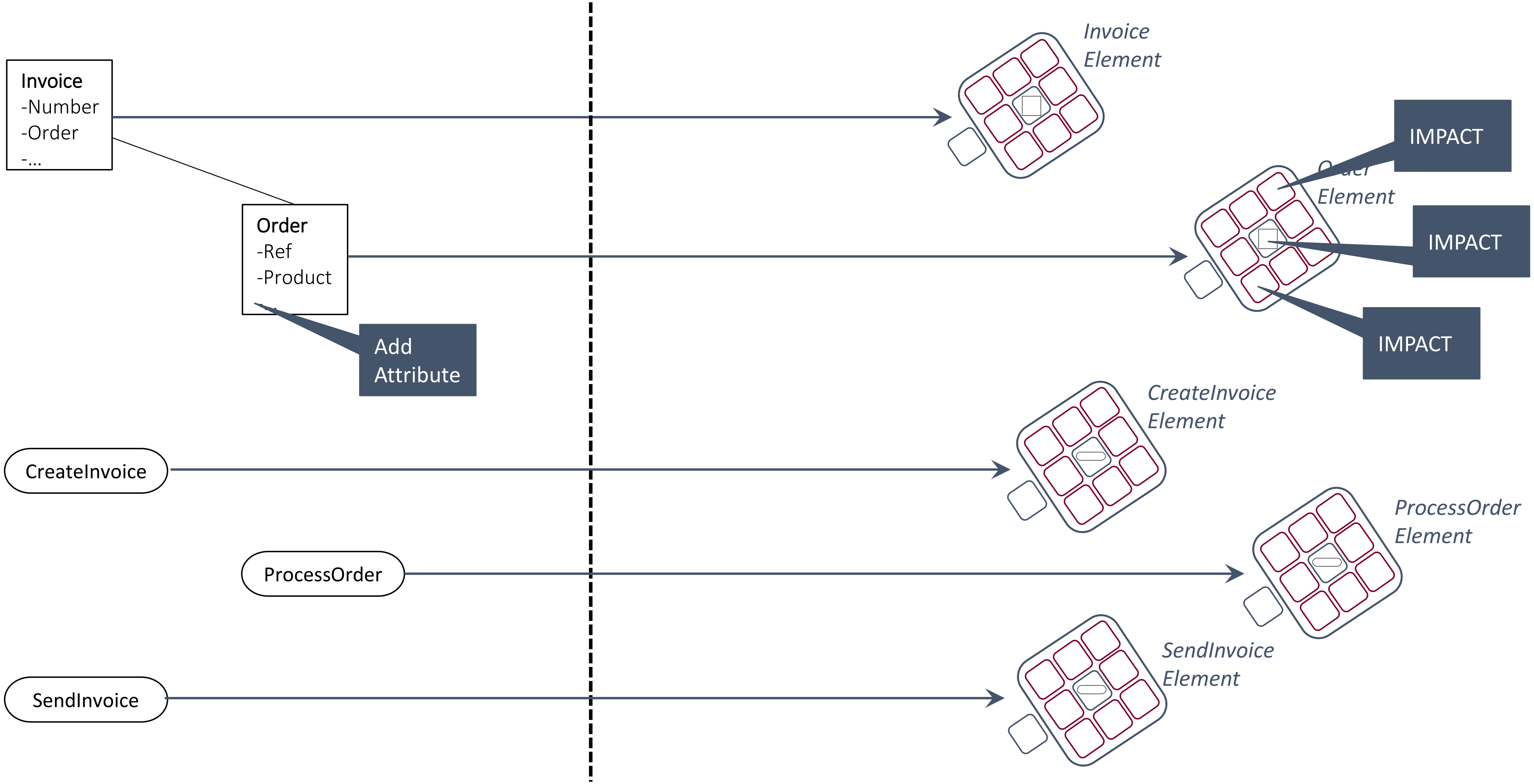


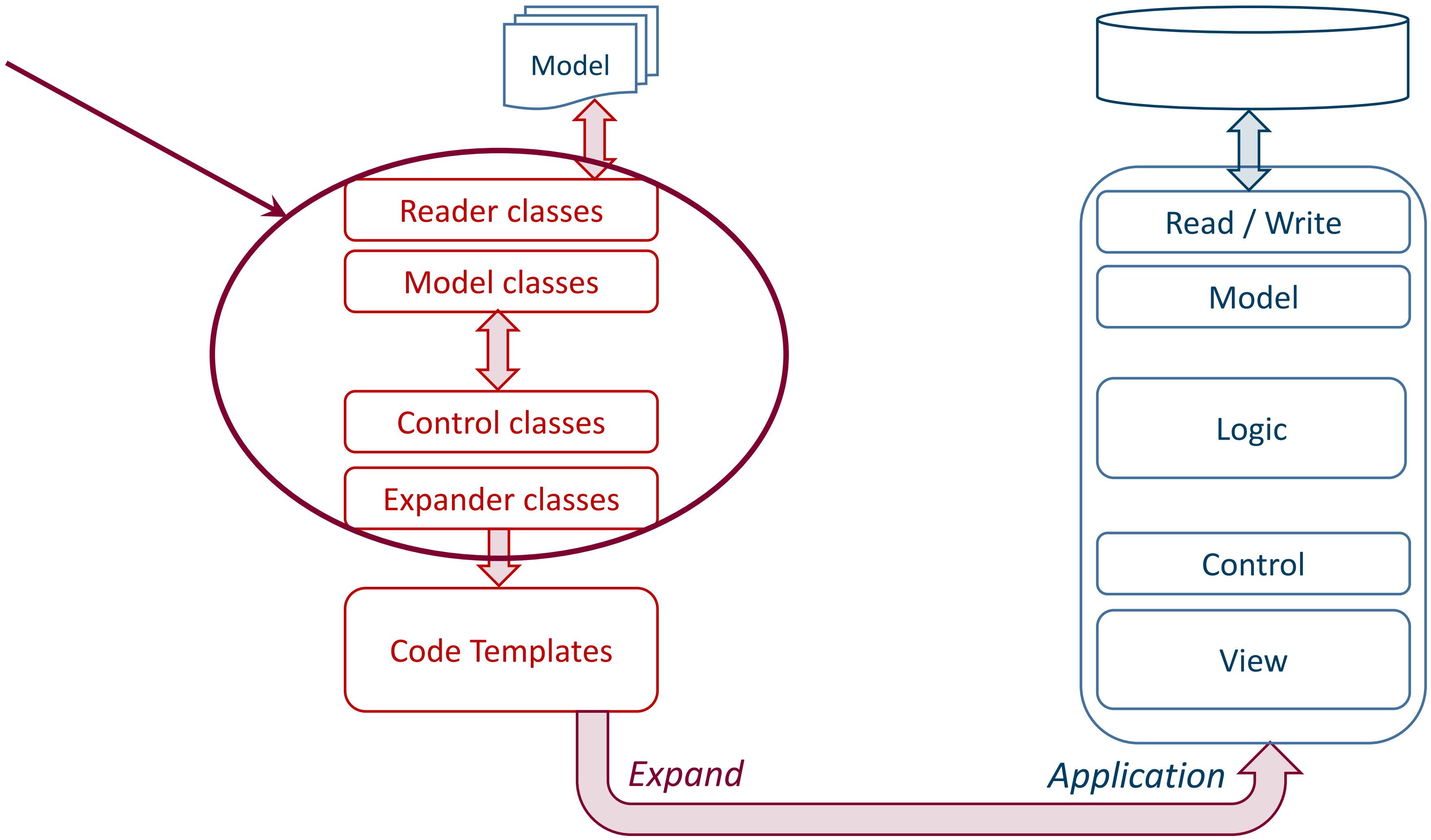
Software Element Instances Create Stable Skeletons



Software Element Instances Create Stable Skeletons

- Element structures are needed *to interconnect with CCC solutions*
- NS defines 5 types of elements, aligned with basic software concepts:
  - ***Data elements***, to represent data variables and structures
  - ***Task elements***, to represent instructions and/or functions
  - ***Flow elements***, to handle control flow and orchestrations
  - ***Connector elements***, to allow for input/output commands
  - ***Trigger elements***, to offer periodic clock-like control
- It seems obvious to use code generation techniques to create instances of these recurrent element structures
- Due to its simple and deterministic nature, we refer to this process as *expansion*, and to the generators as *expanders*

Meta-Circular Code Generation or Artifact Expansion



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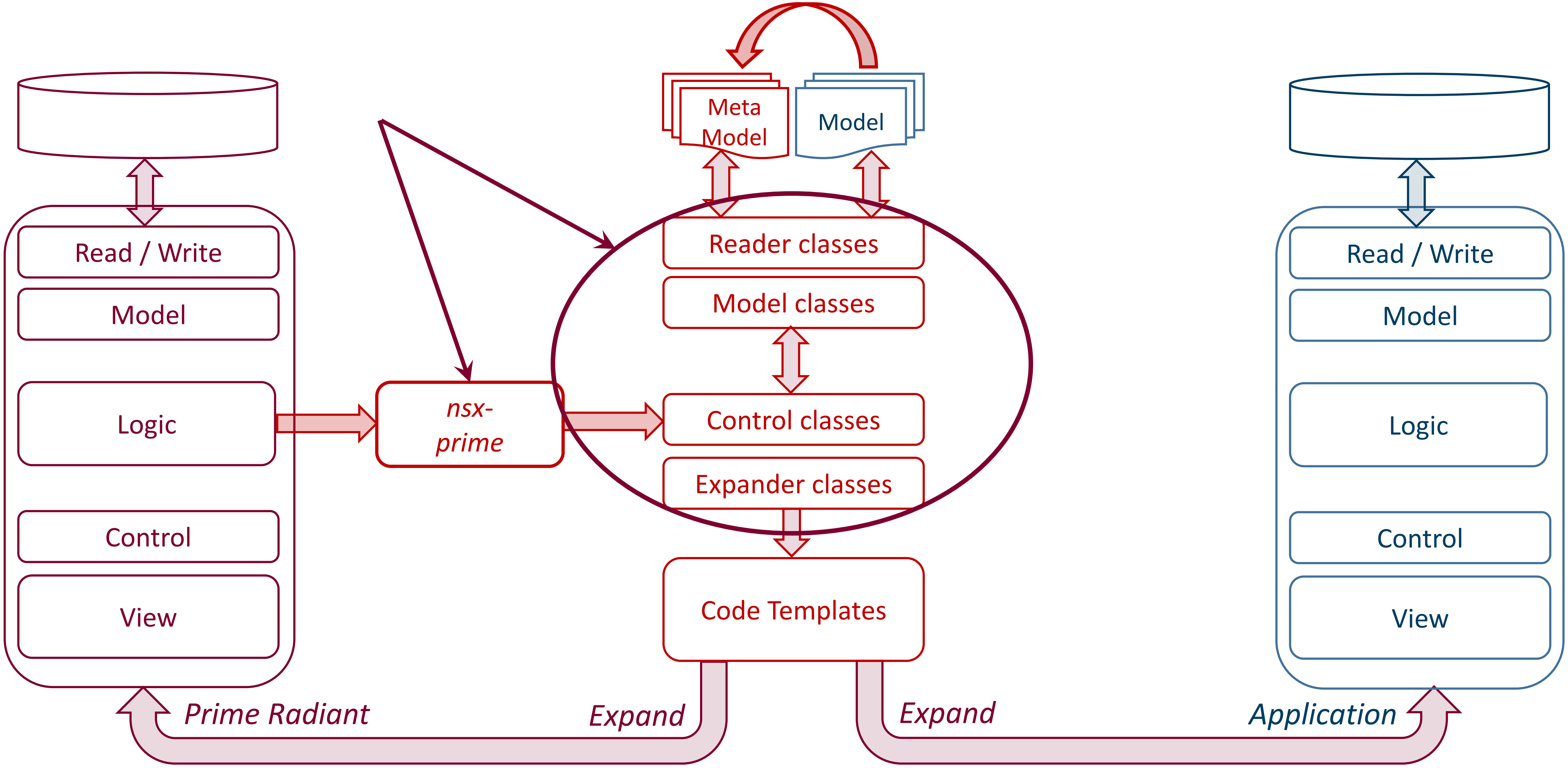

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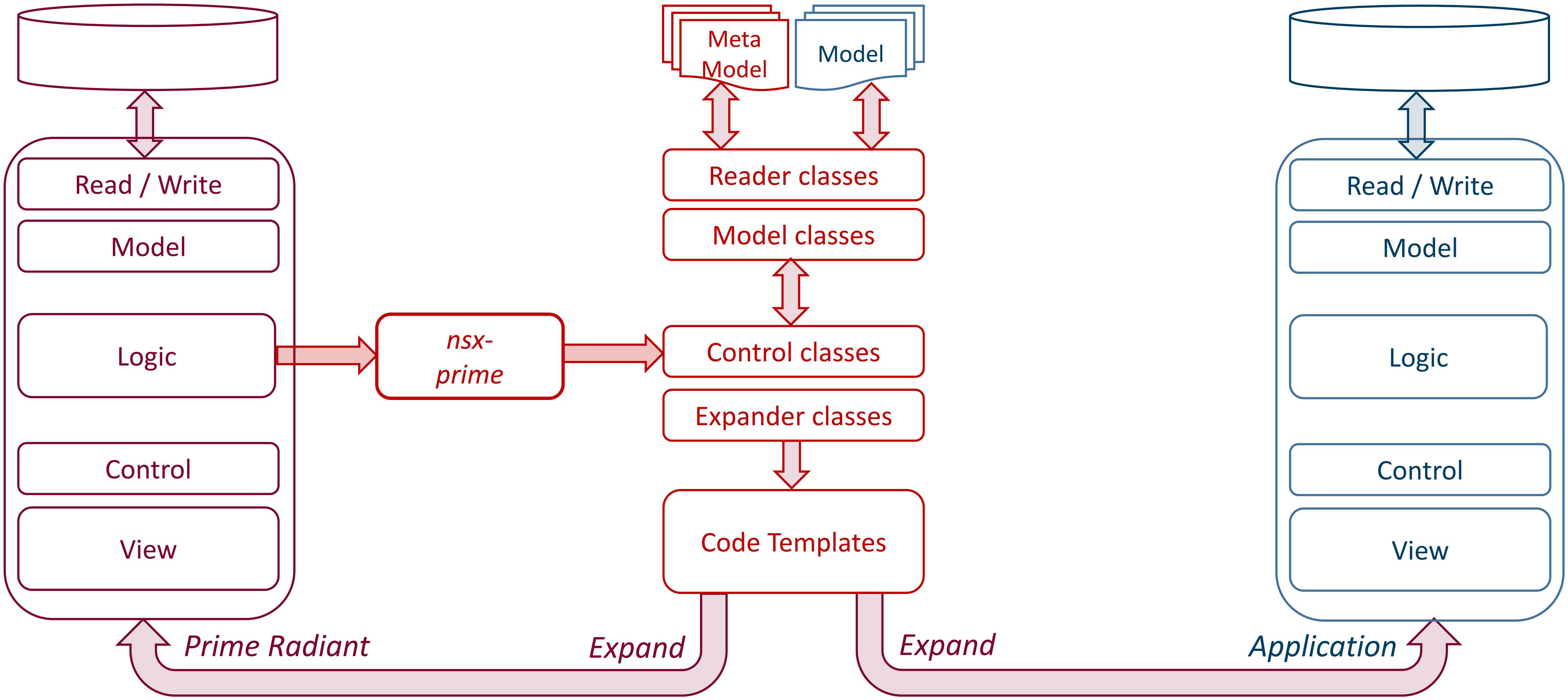

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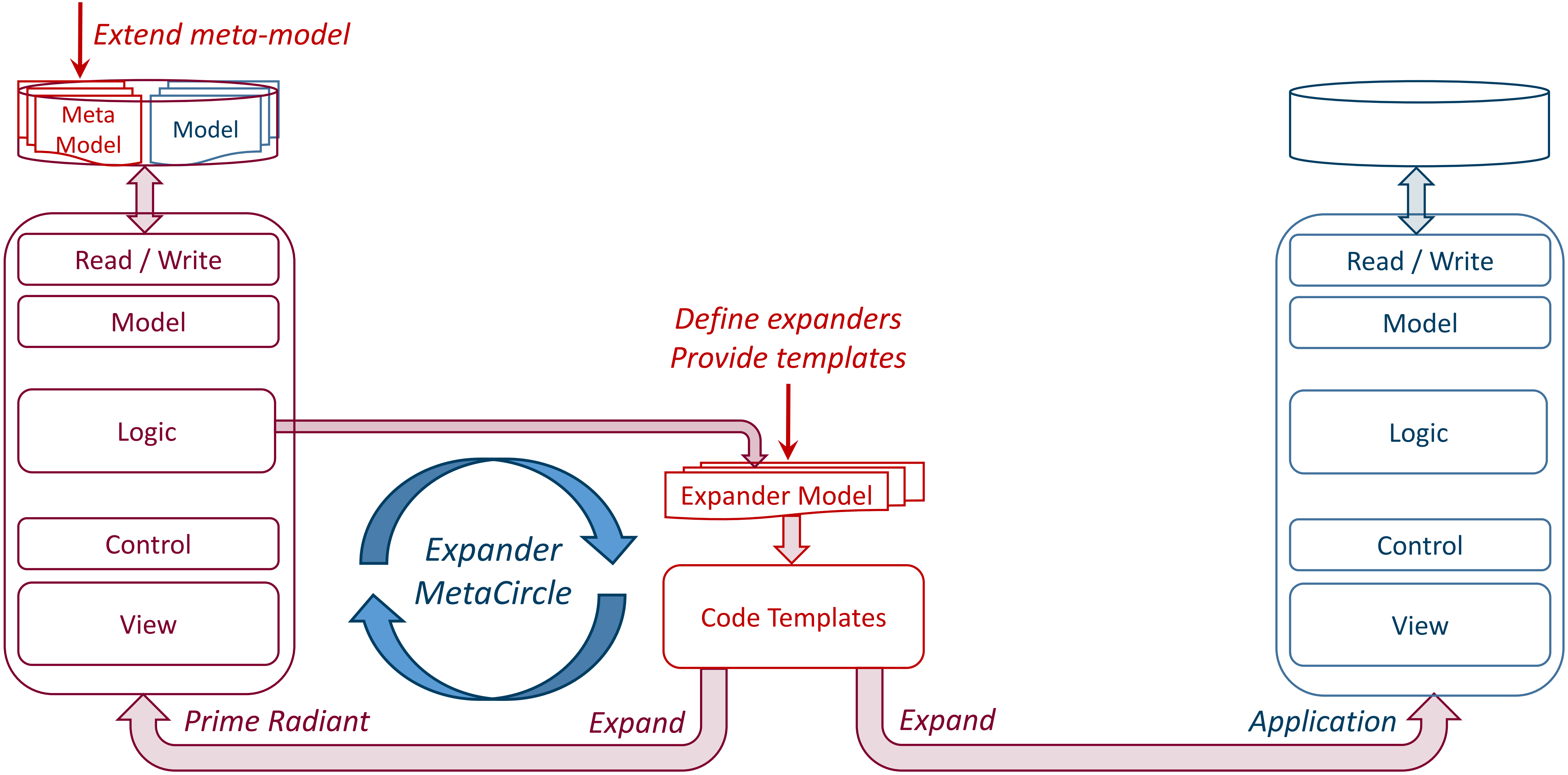

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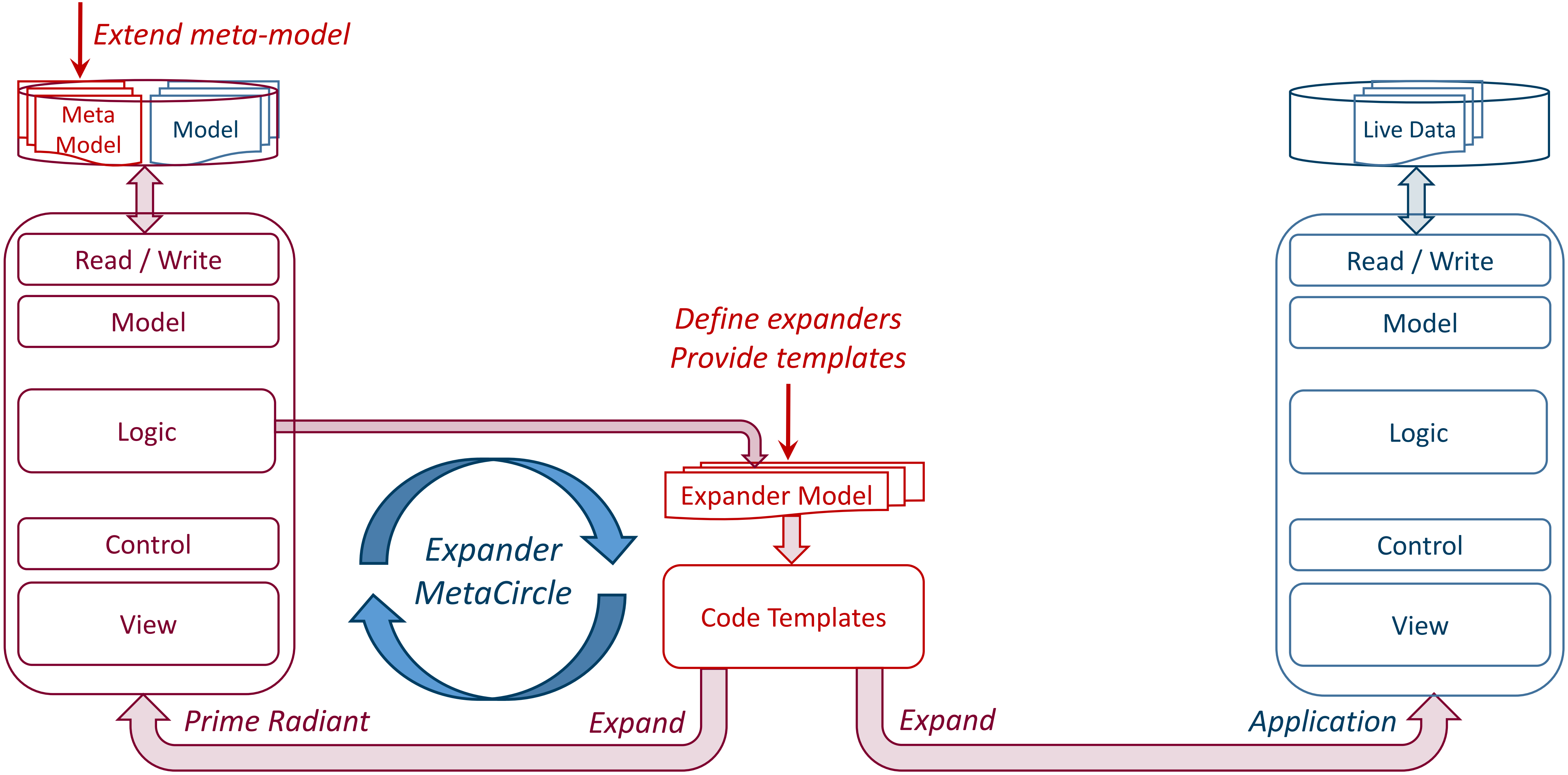

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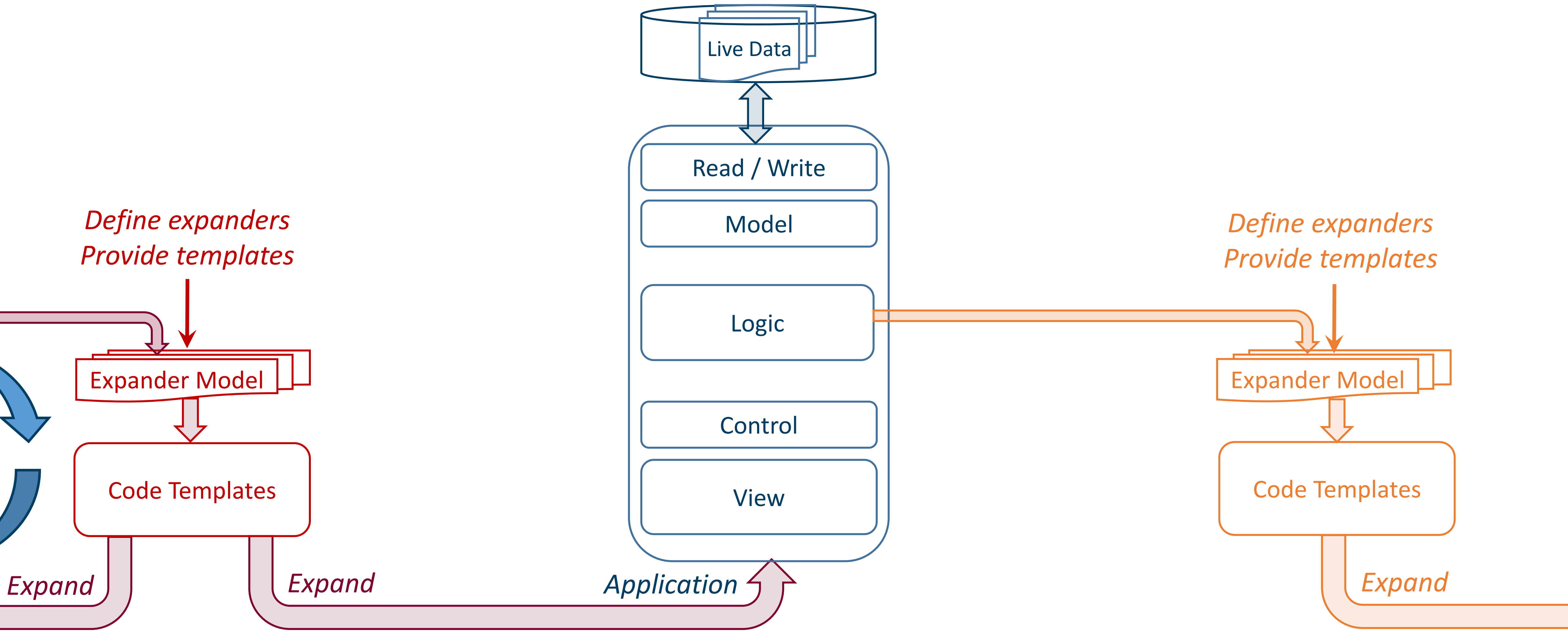

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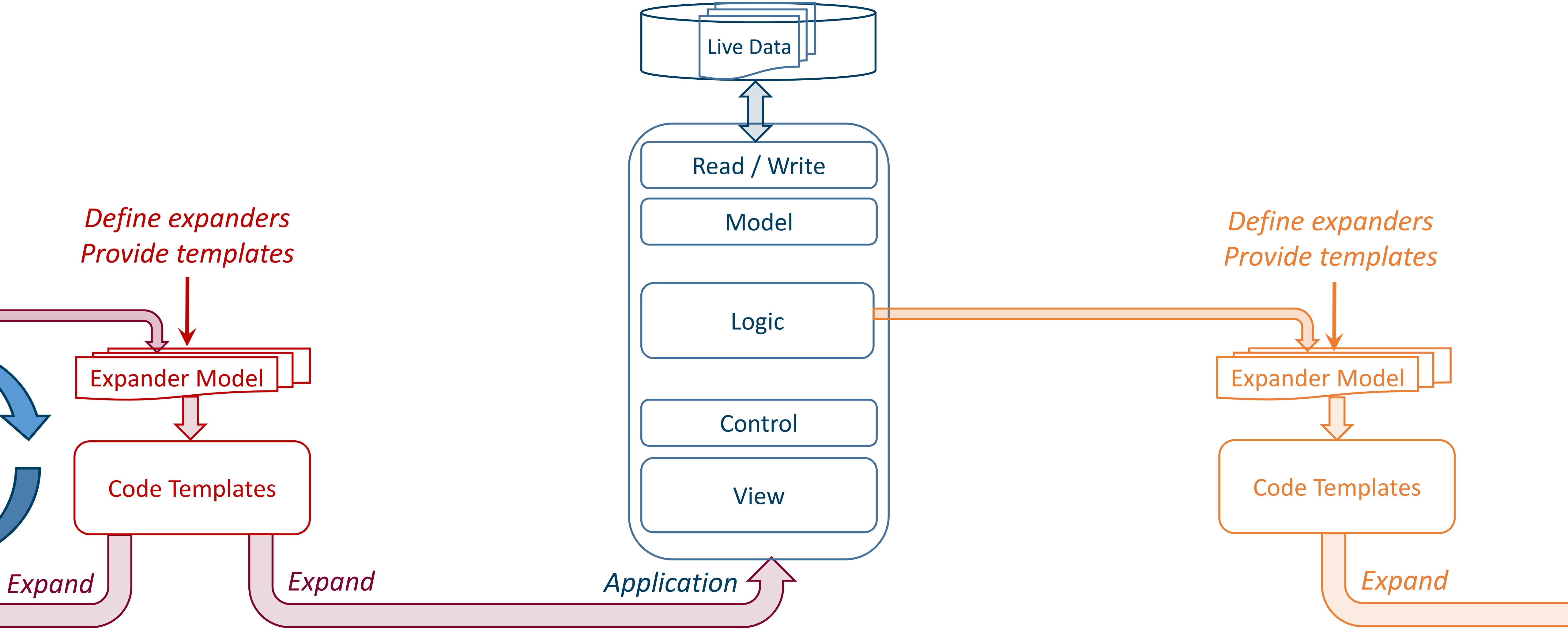

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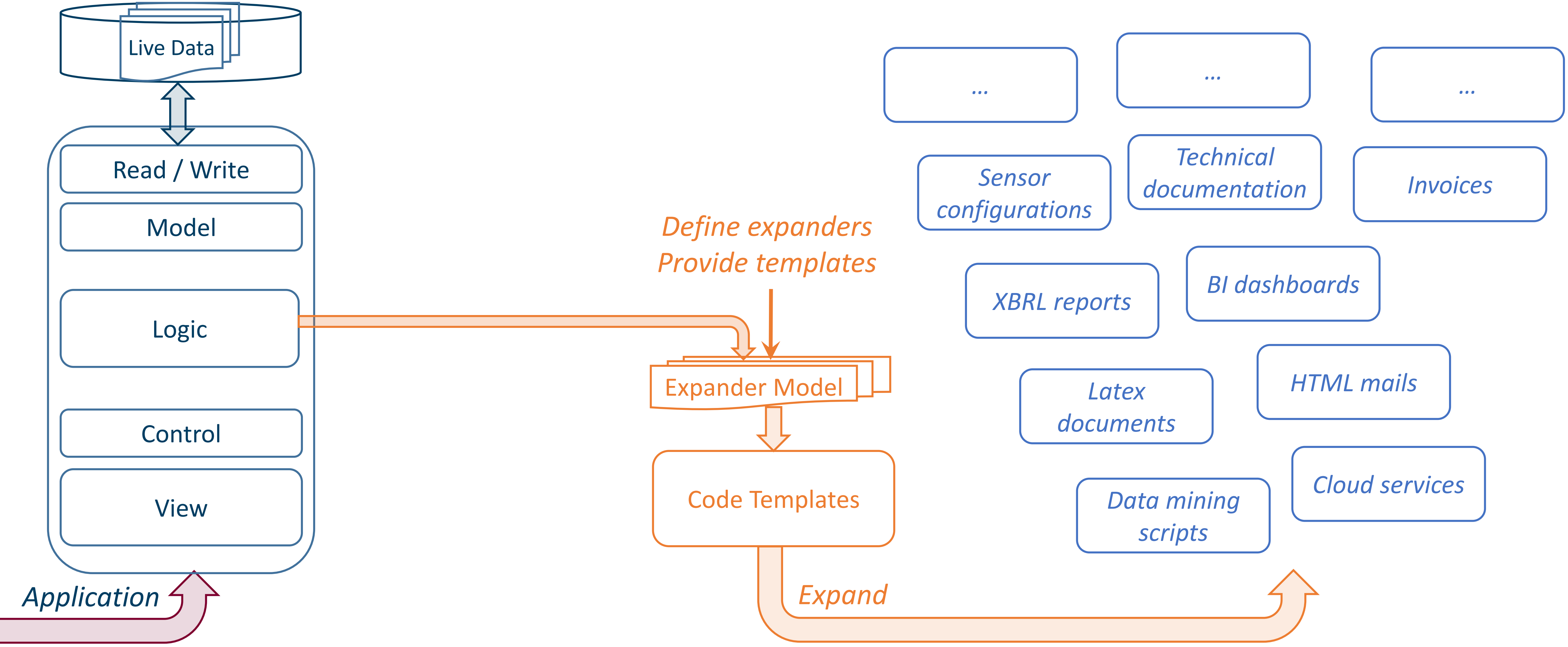

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  - Document Creation and Information Systems
  - Declarative Control and Runtime Expansion
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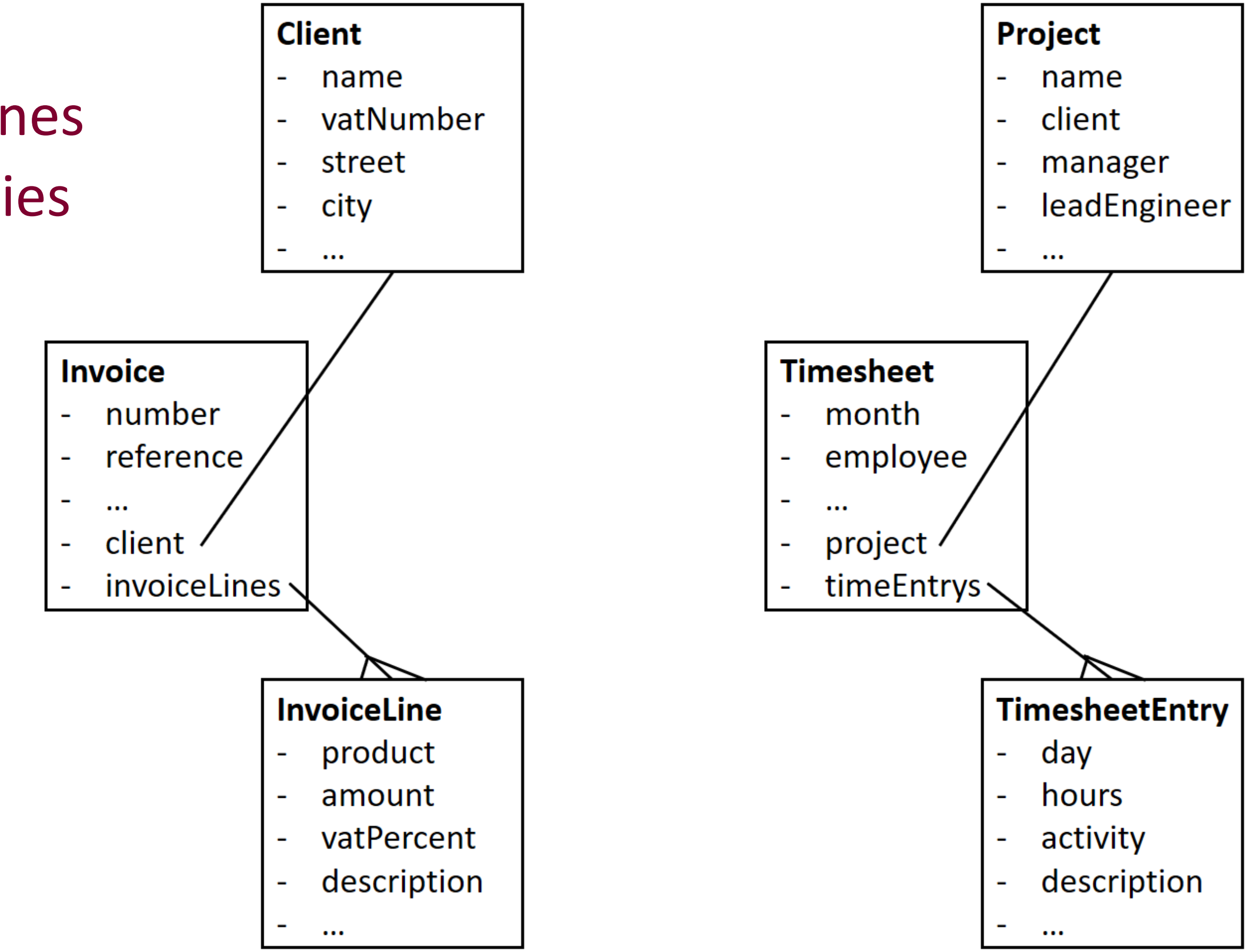
Document Creation and Information Systems

- Interesting duality or synergy:
  - document creation requires an information system
  - information systems typically create documents
- Document creation using NST meta-circular code generation:
  - start from a regular NST information system
  - target simple administrative documents, e.g., *Invoices*, *Timesheets*
  - use model classes to feed runtime-data to the instantiation of documents
- Dedicated development is limited to:
  - Declare document generator or expander, e.g., *TexInvoiceExpander*
  - Define parameters using OGNL expressions, e.g., *TexInvoiceExpanderMapping*
  - Write LaTeX template containing the defined instance parameters

Declarative Control and Runtime Expansion

- Take two simple examples:
  - **Invoice** for Client with InvoiceLines
  - **Timesheet** for Project with Entries



Declarative Control and Runtime Expansion

TexInvoiceExpander.xml

```
<expander name=“TexInvoiceExpander"
          xmlns="http://nsx.normalizedsystems.org/20201/expander">
  <packageName>net.palver.expander.latex.invoice</packageName>
  <elementTypeName>Invoice</elementTypeName>
  <layerType name=“ROOT"/>
  <technology name="COMMON"/>
  <sourceType name=“TEX"/>
  <artifactName>Invoice-$invoice.number$.tex</artifactName>
  <artifactPath>$expansion.directory$/$artifactSubFolders$/</artifactPath>
  <isApplicable>true</isApplicable>
  <active value="true"/>
  <anchors/>
</expander>
```

TexInvoiceExpanderMapping.xml

```
<mapping xmlns="http://nsx.normalizedsystems.org/202001/expanders/mapping">

  <value name=“info" eval=“invoice.info"/>
  <value name=“number" eval=“invoice.number"/>
  <value name=“client" eval=“invoice.client.name"/>
  <value name=“vatNr" eval=“invoice.client.vatNr"/>
  <value name=“street" eval=“invoice.client.street"/>
  <value name=“city" eval=“invoice.client.city"/>
  <value name=“isForeign" eval=“!invoice.client.country.equals(‘Belgium’)"/>

  <list name=“invoiceLines” eval=“invoice.invoiceLines” param=“invoiceLine”>
    <value name=“info" eval=“invoiceLine.info"/>
    <value name=“product" eval=“invoiceLine.product"/>
    <value name=“amount" eval=“invoiceLine.amount"/>
  </list>
</mapping>
```

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Conclusions

- We adapted the NST metaprogramming environment:
  - to produce sources for documents or files
  - based on runtime data in regular NS applications
  - through declarative definitions and OGNL evaluations
- Such a document generation environment:
  - adheres to concepts like single sourcing and CCM
  - takes advantage of existing flexibility ad robustness
- Implementation is an architectural pathfinder:
  - creating currently only simple documents

Some References

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- **Normalized Systems Foundation Lectures** : https://www.youtube.com/channel/UCc8P1LREJogSlhwmAvdkq2A
- **Normalized Systems Prime Radiant Online:** https://foundation.stars-end.net **and** https://exchange.stars-end.net

QUESTIONS ?

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