HANDLING CONFLICTING REQUIREMENTS

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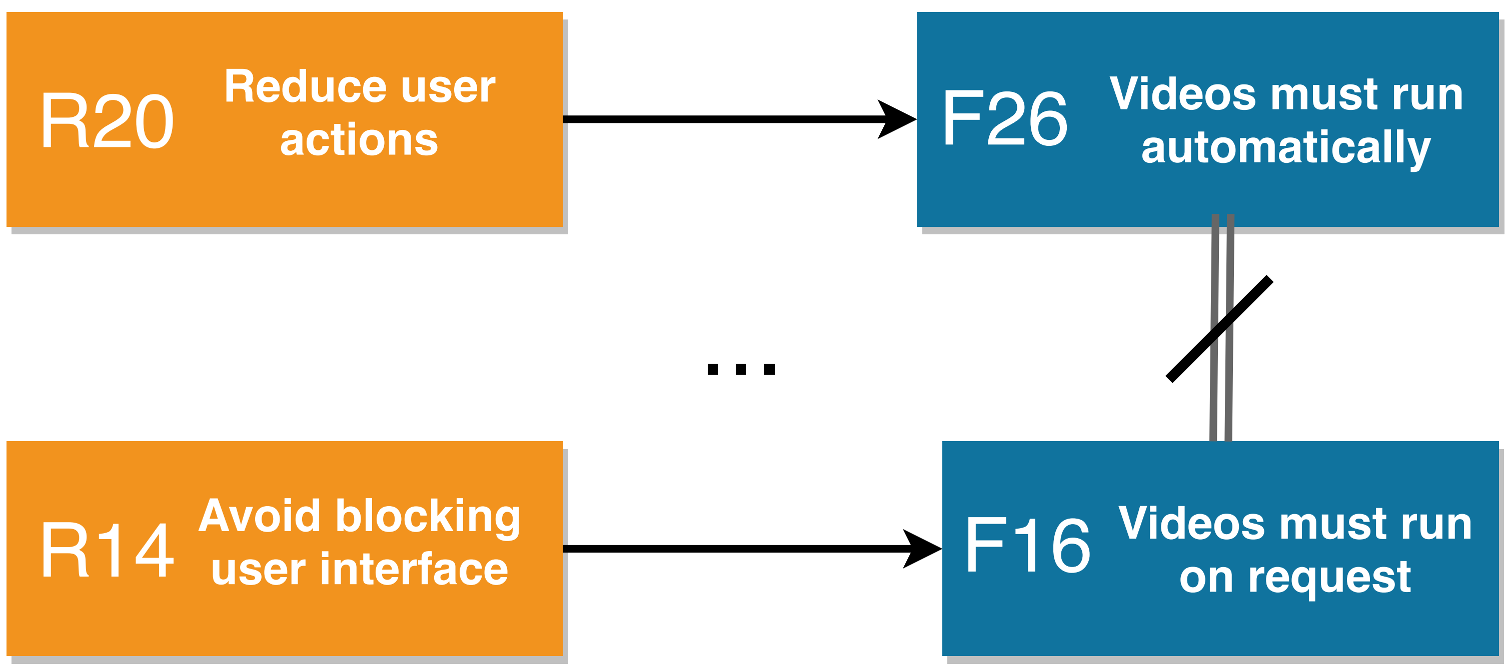
OUTLINE

- Introduction
- Examples
- Techniques
- Summary

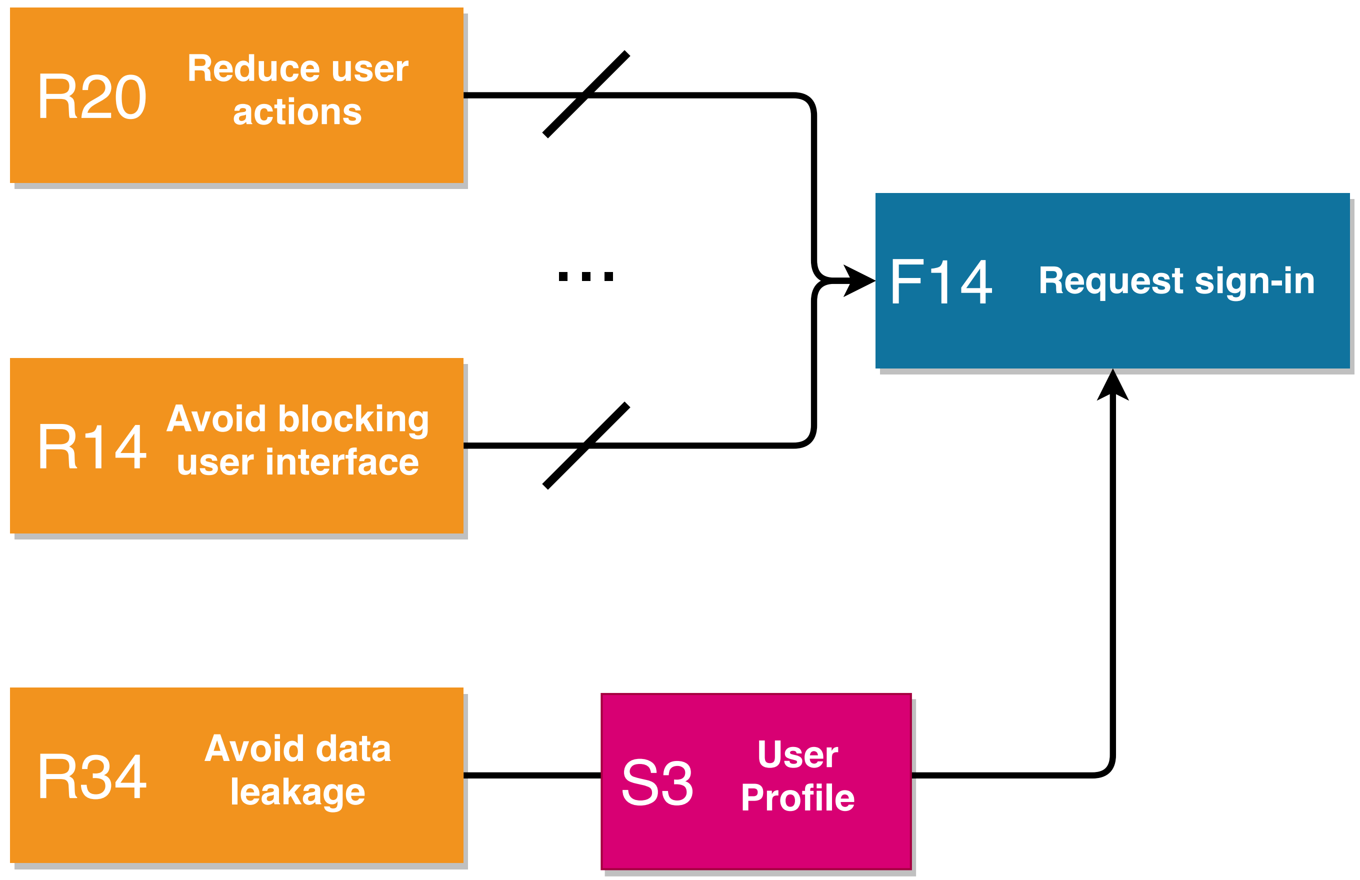
INTRODUCTION

EXAMPLE 1 – MULTIPLE STAKEHOLDERS

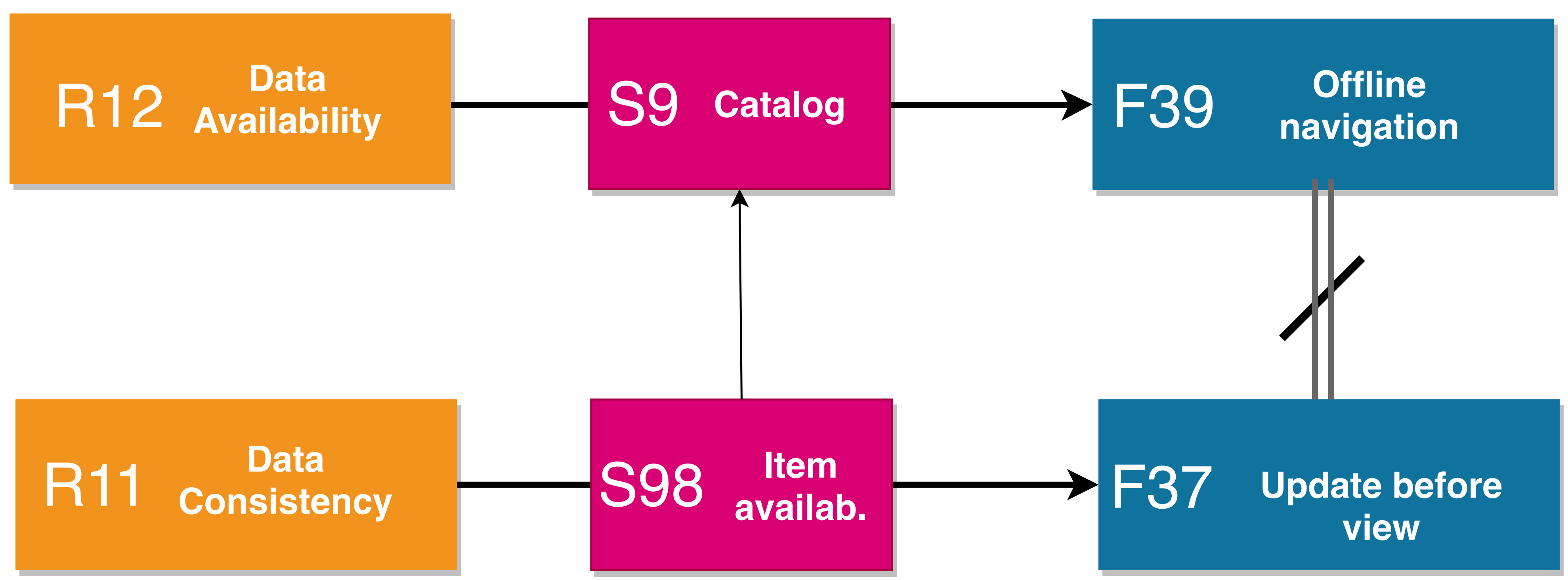
EXAMPLE 2 – CONFLICTING FEATURES



EXAMPLE 3 – CONFLICTING DEPENDENCIES



EXAMPLE 4 – CONFLICTING DEPENDENCIES FOR KR



EXAMPLE 5 – CONFLICTING KR

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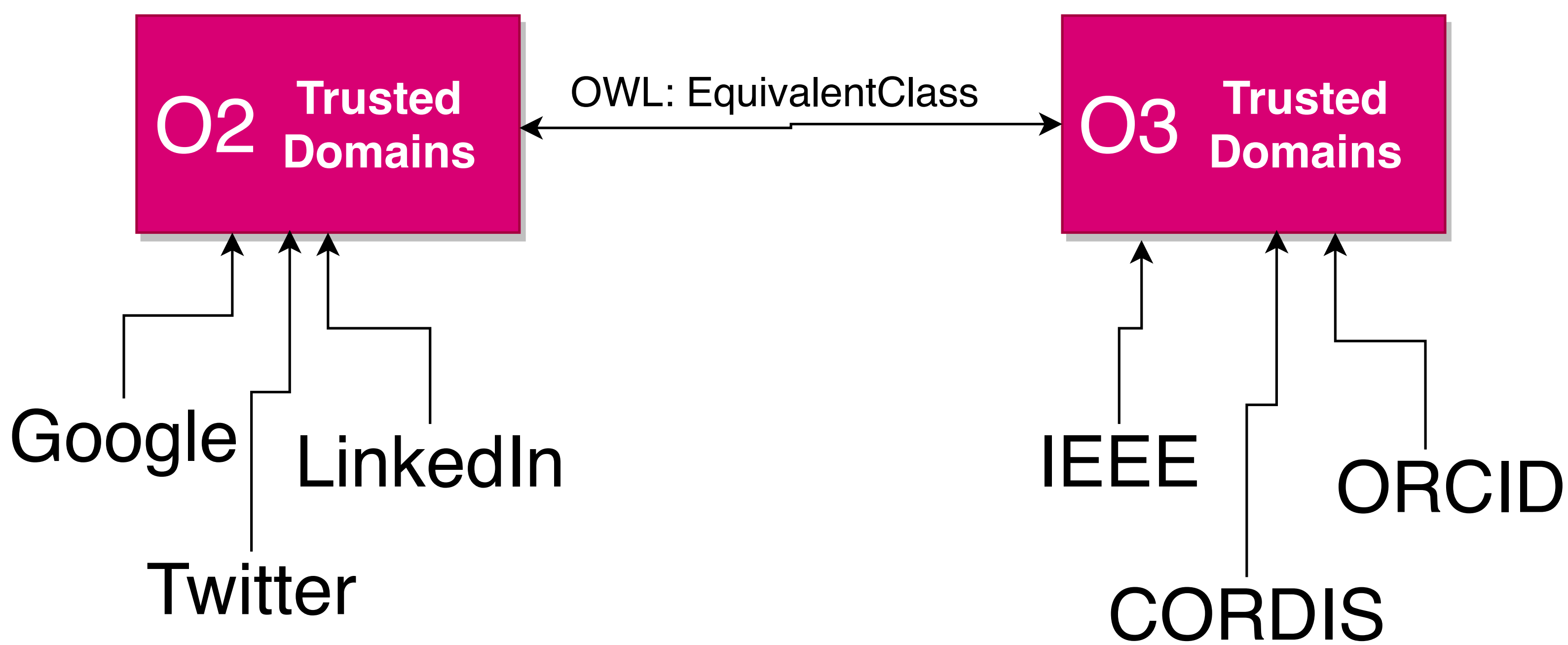
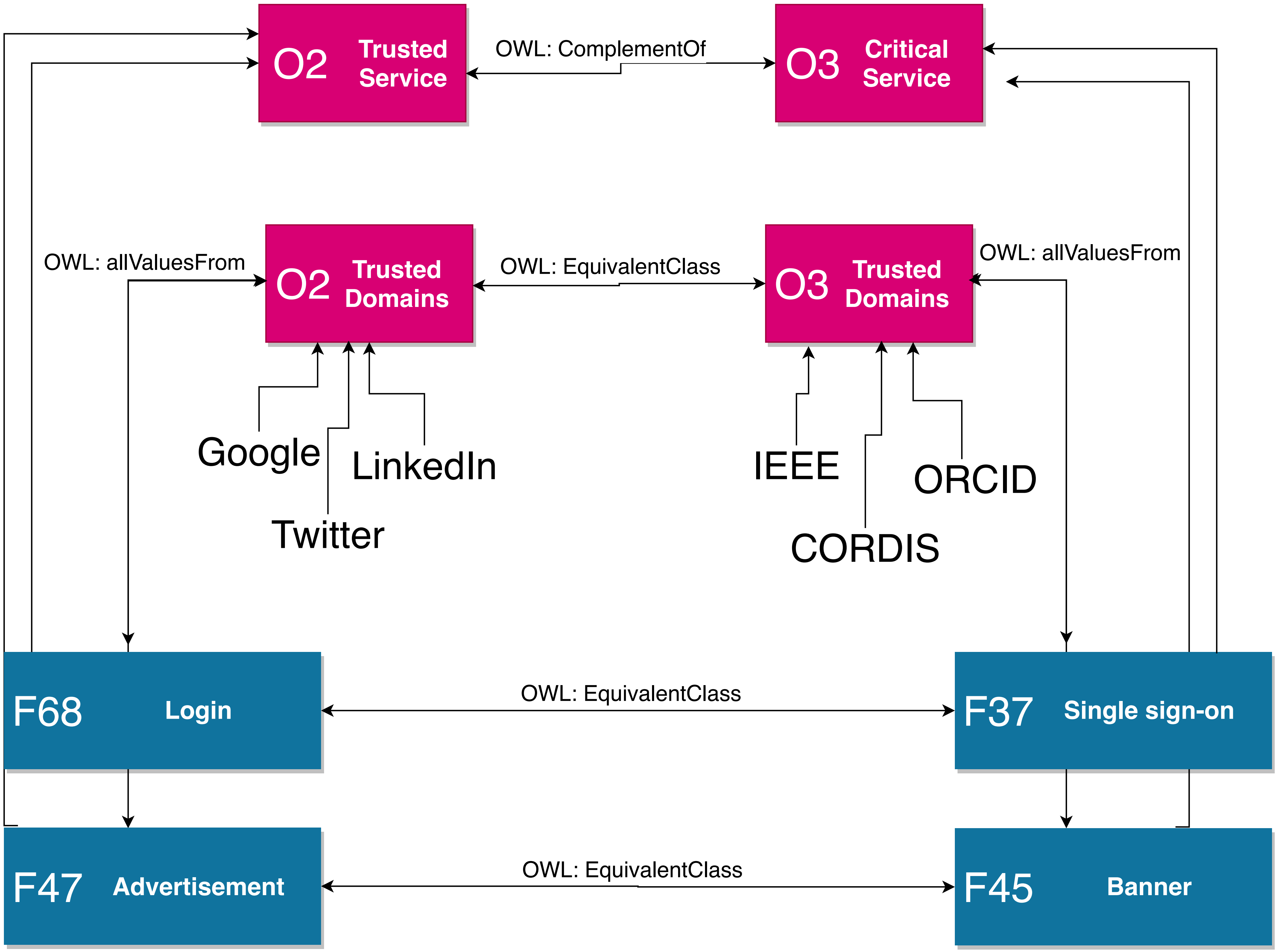
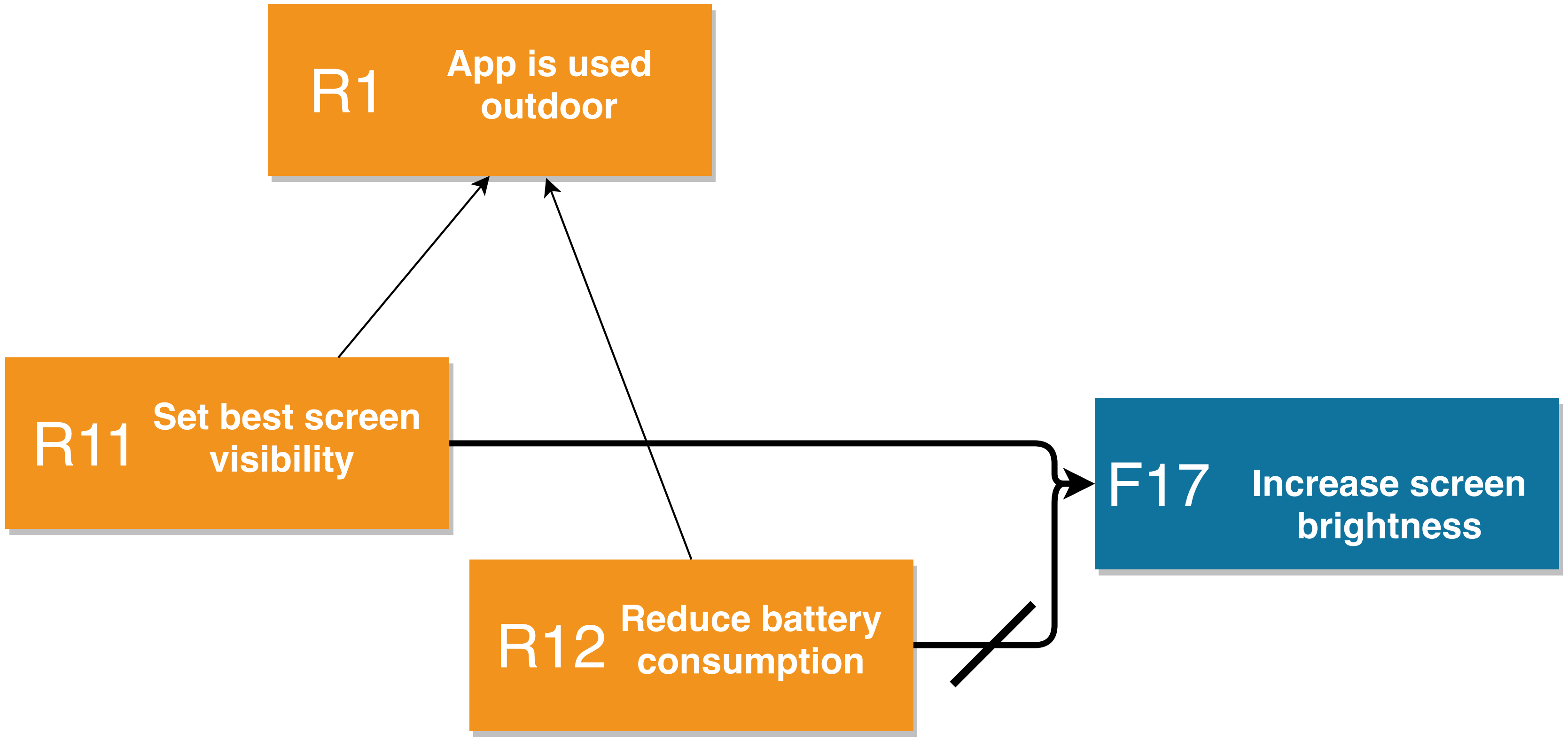


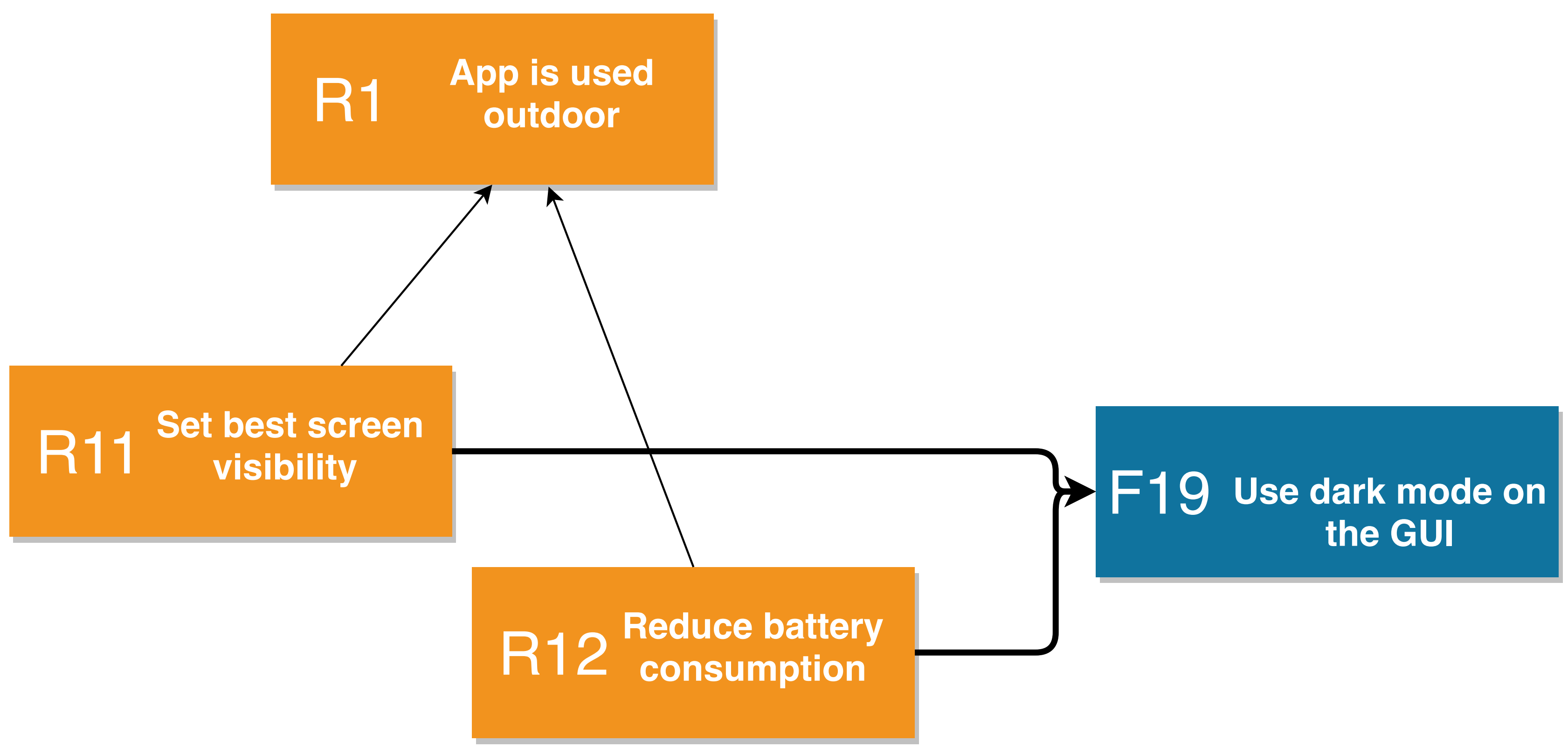
EXAMPLE 6 – APPARENT CONFLICTING KR



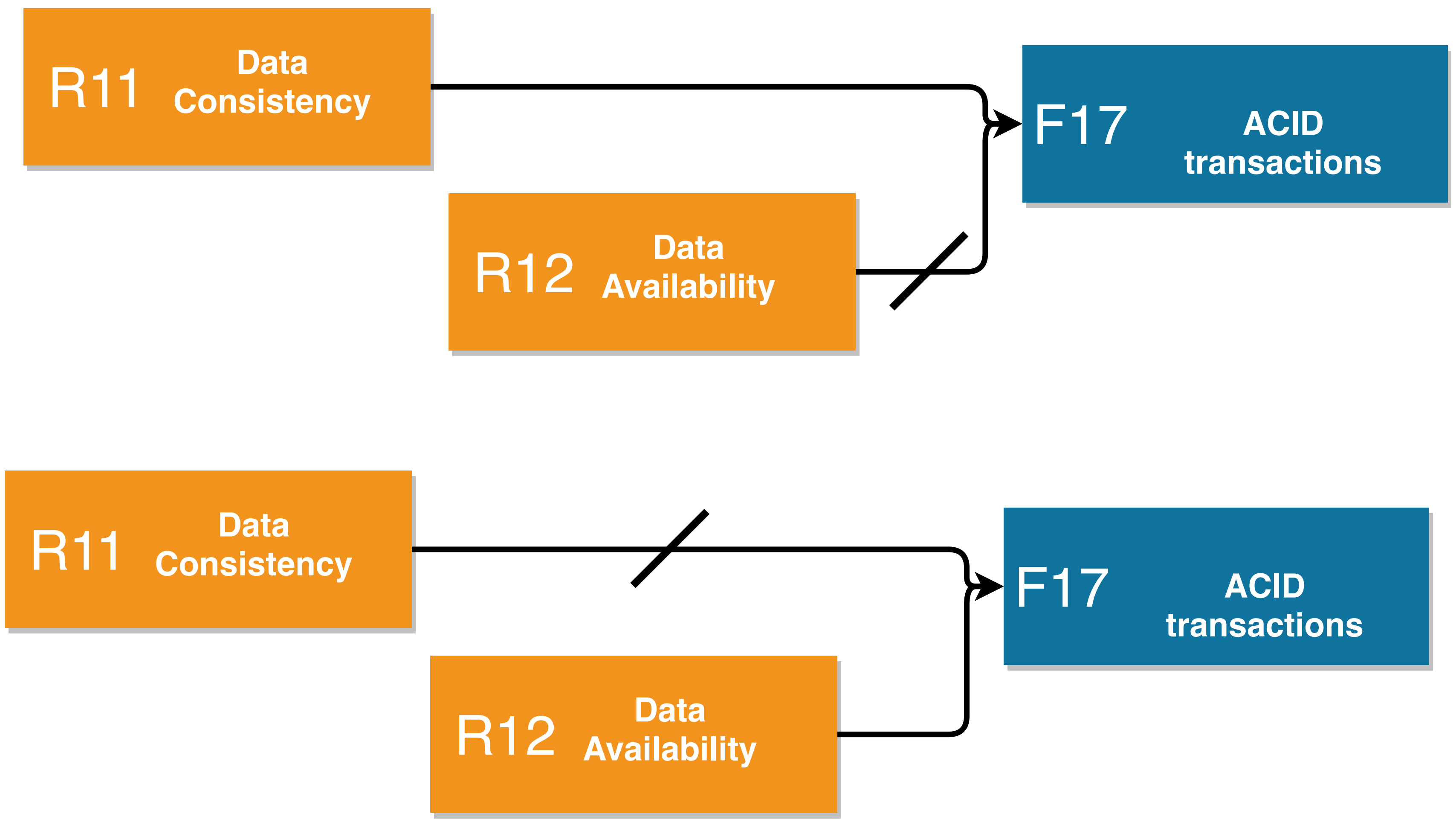
EXAMPLE 6 – APPARENT CONFLICT



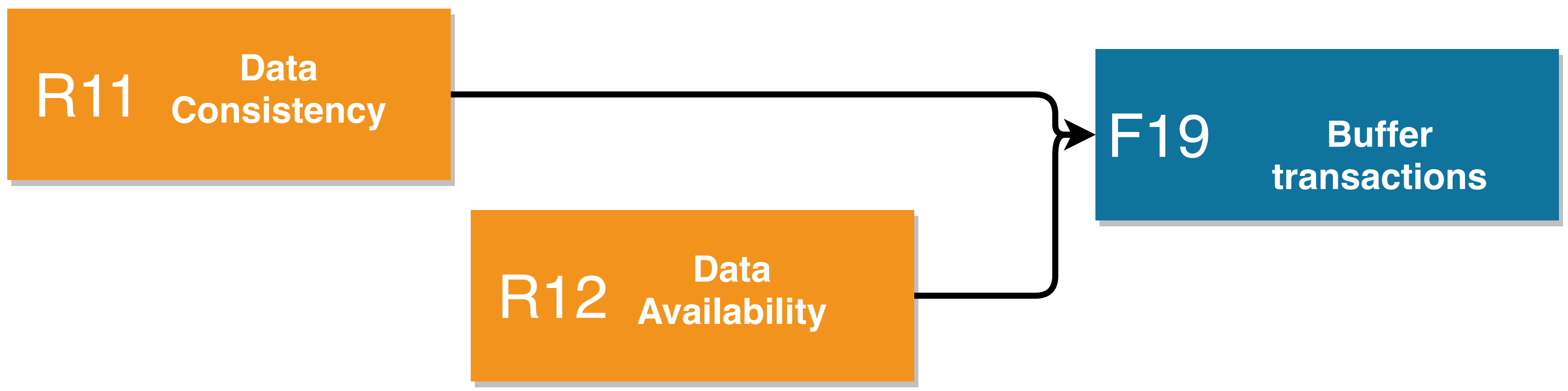
EXAMPLE 6 – APPARENT CONFLICT: NEW SOLUTION



EXAMPLE 7 – APPARENT CONFLICT



EXAMPLE 7 – APPARENT CONFLICT: TRADE-OFF



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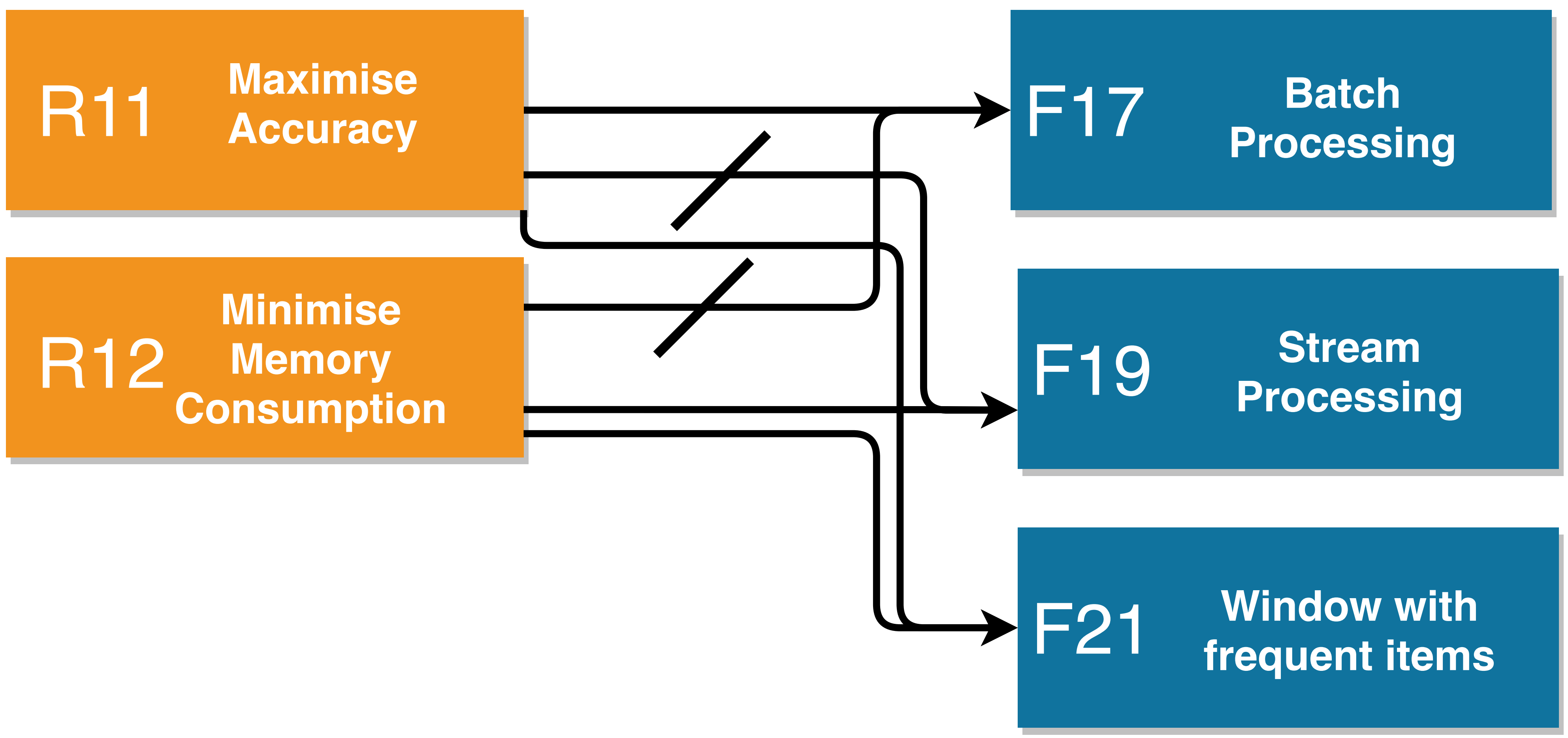

KNOWLEDGE REPRESENTATION

- If requirements and specifications are associated with a **formal semantics** we can use automated reasoning to detect inconsistencies
  - Following the **classical principle of non-contradiction**, KR languages consider invalid any set of assertions bringing to a contradictory proposition
    - To solve inconsistencies the goal is **isolating the minimal inconsistent subset**
      - This operation **grows exponentially** with the number of assertions in the knowledge base
      - Greedy methods can be used but human intervention cannot be avoided

- In Hussain et al. an example following the structure below generated 98132 possible **resolve candidates**

```
# Ontology Org A
o1:UserAccount
  rdfs:subClassOf
    [ a owl:Restriction ;
 owl:maxCardinality 1;
 owl:onProperty o1:recoveryPhone;
 ]

# Data Org B
o2:UserA o2:recovery "+393287738".
o2:UserA o2:recovery "+393287654".

# Mapping ontologies A and B
o2:UserA rdf:type o1:UserAccount.
"+393287738" owl:differentFrom "+393287654".
o1:recoveryPhone owl:equivalentProperty o2:recovery.
```

Sajjad Hussain, Jos De Roo, Ali Daniyal, and Syed Sibte Raza Abidi. Detecting and resolving inconsistenciesin ontologies using contradiction derivations. In2011 IEEE 35th Annual Computer Software and ApplicationsConference, pages 556–561. IEEE, 2011

KNOWLEDGE REPRESENTATION

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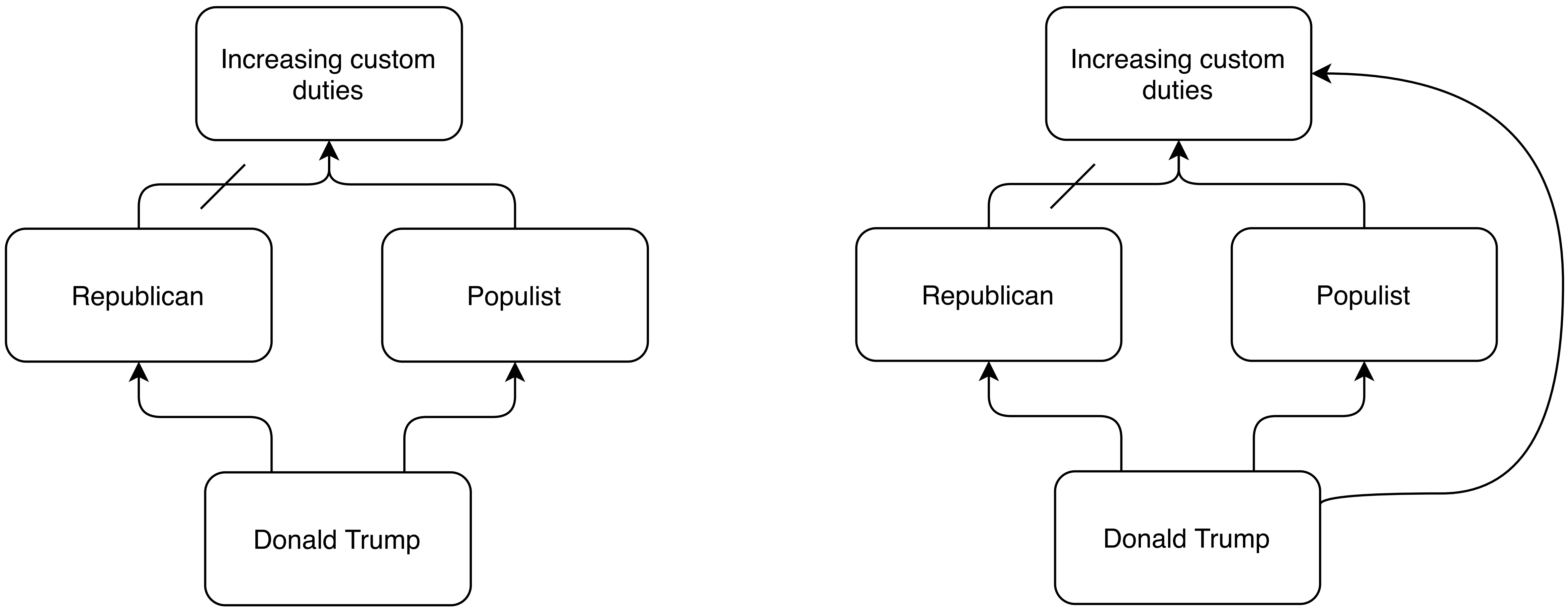
- Defeasible reasoning is an alternative
  - Reasoning does not produce a full or final demonstration
  - Its conclusions go beyond the premises
  - Integrating common sense and expert knowledge

$$T_{8.4} = \left\{ \begin{array}{l} r_1 : \mathsf{Bird}^* \sqsubseteq \mathsf{Flies}^* \sqcap \mathsf{Animal} \\ r_2 : \mathsf{Eagle} \sqsubseteq \mathsf{Bird} \\ r_3 : \mathsf{Penguin}^* \sqsubseteq \mathsf{Bird}^* \sqcap (\neg \mathsf{Fly})^* \end{array} \right\}.$$

$$Lam_{\mathsf{Penguin}}(T_{8.4}) = \mathsf{Bird}, \mathsf{Flies}, \mathsf{Penguin}, (\neg \mathsf{Flies}).$$

Alejandro Gomez, Sergio, Carlos Ivan Chesnevar, and Guillermo Ricardo Simari. "Reasoning with inconsistent ontologies through argumentation." Applied Artificial Intelligence 24, no. 1-2 (2010): 102-148.

- Defeasible reasoning is an alternative



t_1 t_2

Horty, John F., Richmond H. Thomason, and David S. Touretzky. "A skeptical theory of inheritance in nonmonotonic semantic networks." Artificial intelligence 42, no. 2-3 (1990): 311-348.

KR - LESSON LEARNED

- Knowledge unification bring to intractable knowledge
- Explicit representation of conflicts in knowledge simplify both detection and resolution

DEPENDENCIES

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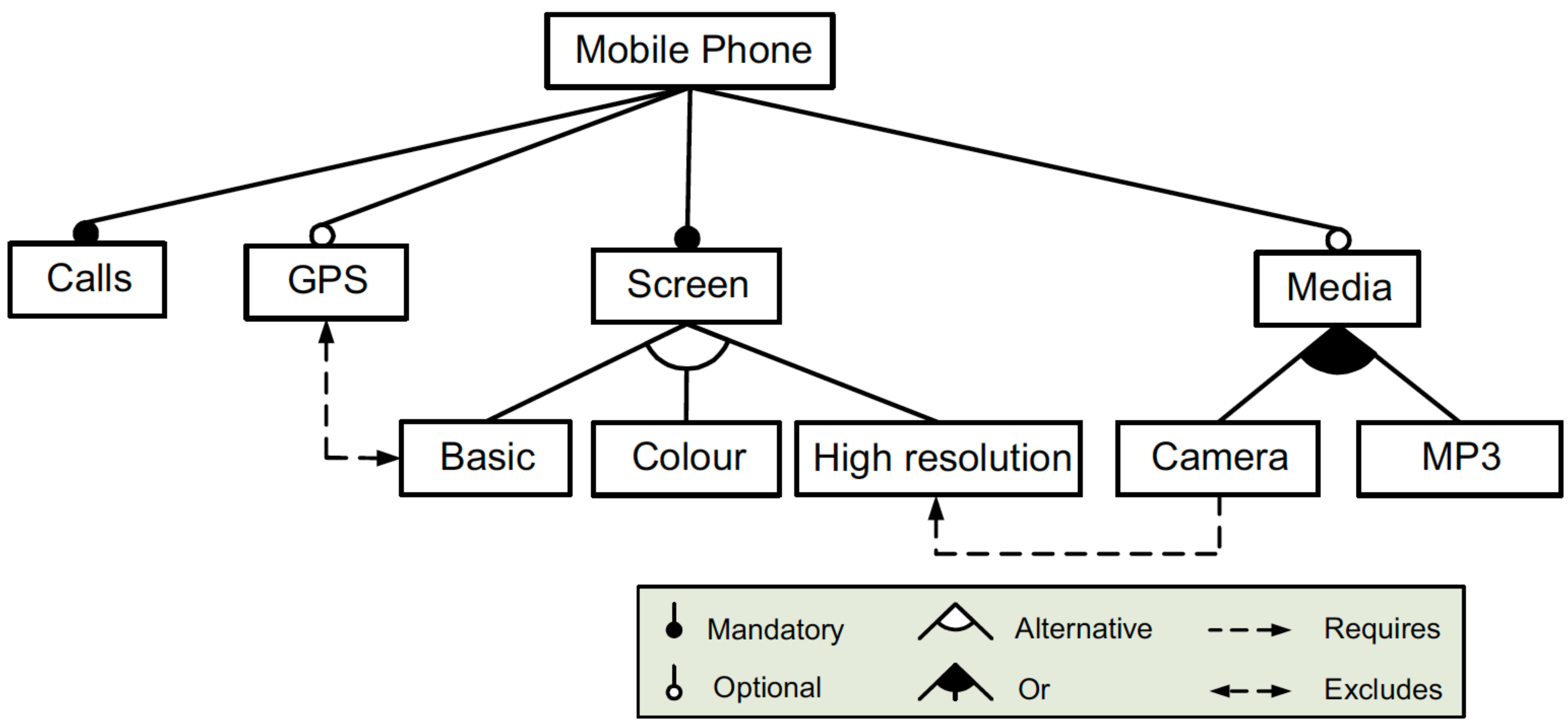
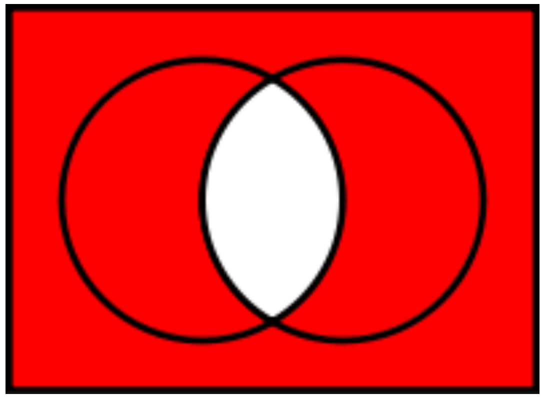
- The explicit representation of dependencies between features and requirements is often adopted in Software Engineering



Benavides, David, Sergio Segura, and Antonio Ruiz-Cortés. "Automated analysis of feature models 20 years later: A literature review." Information systems 35, no. 6 (2010): 615-636.

DEPENDENCIES

- In terms of propositional calculus a conflicting requirement can be interpreted as an **alternative denial**, the negation of the conjunction
  - $P \rightarrow \neg Q$ equivalent to $\neg P \vee \neg Q$



- When propositions are correctly gathered detection is easy
- To resolve conflicts priority and specificity are typical criteria

DEPENDENCIES

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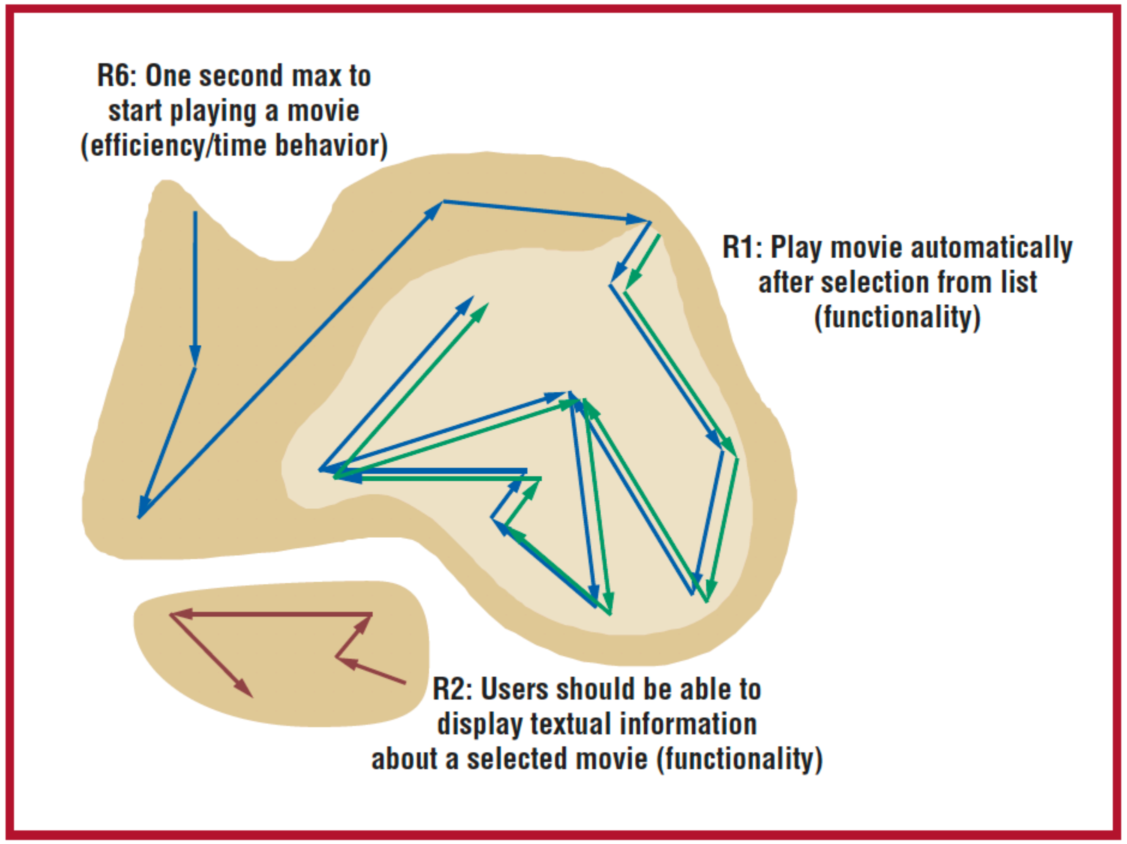
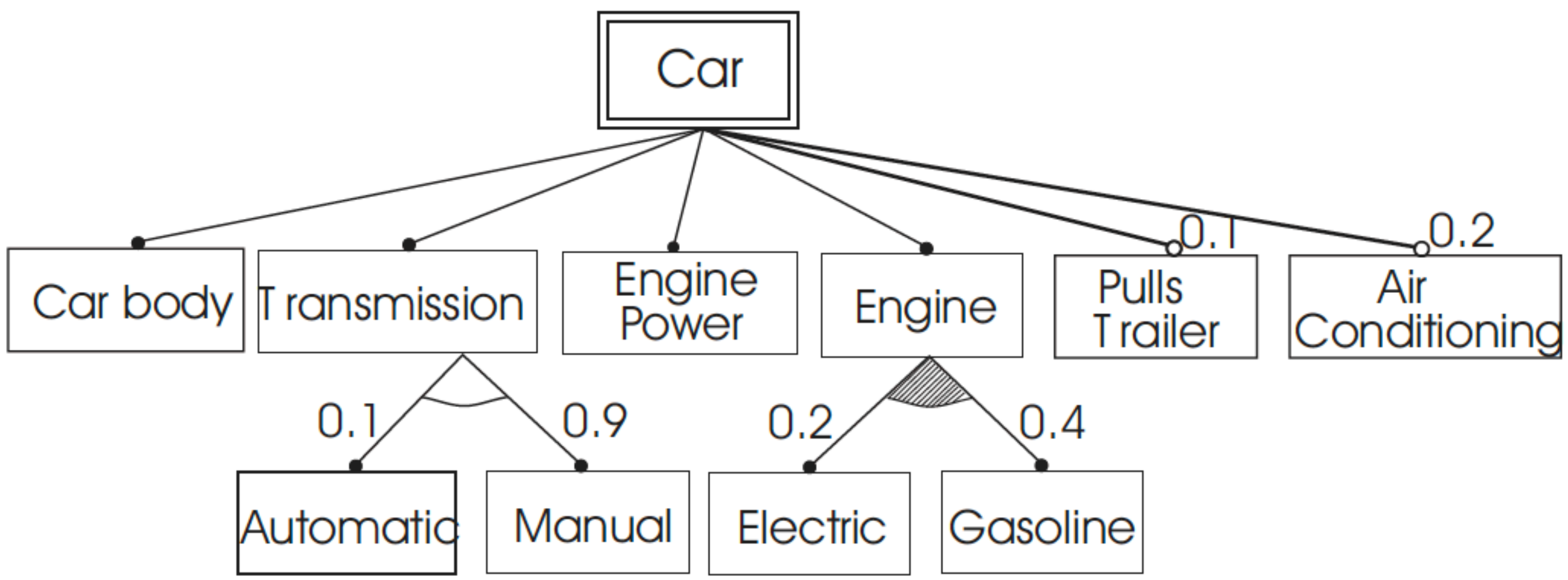
Model of potential conflict and cooperation*

Requirement attribute	Effect							
	Functionality	Efficiency	Usability	Reliability	Security	Recoverability	Accuracy	Maintainability
Functionality	+	–	+	–	–	0	0	–
Efficiency	0	+/–	+	–	–	0	–	–
Usability	+	+/–	+	+	0	+	+	0
Reliability	0	0	+	+	0	0	0	0
Security	0	–	–	+	+	0	0	0
Recoverability	0	–	+	+	0	+	0	0
Accuracy	0	–	+	0	0	0	+	0
Maintainability	0	0	0	+	+	0	0	+

Egyed, A., & Grunbacher, P. (2004). Identifying requirements conflicts and cooperation: How quality attributes and automated traceability can help. IEEE software, 21(6), 50-58.

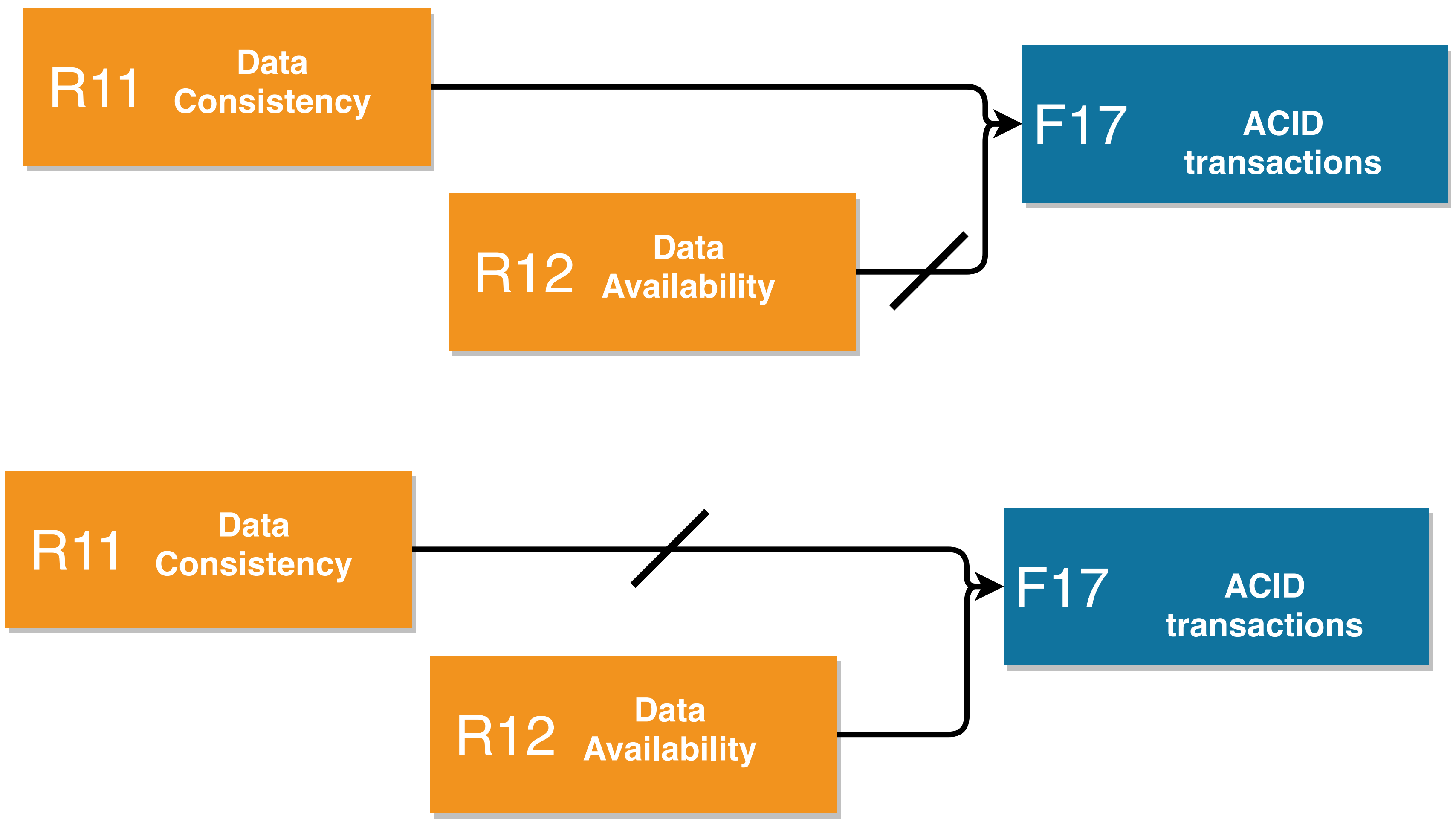


DEPENDENCIES



Robak, Silva, and Andrzej Pieczynski. "Employing fuzzy logic in feature diagrams to model variability in software product-lines." In 10th IEEE International Conference and Workshop on the Engineering of Computer-Based Systems, 2003. Proceedings., pp. 305-311. IEEE, 2003.

EXAMPLE 7 – APPARENT CONFLICT



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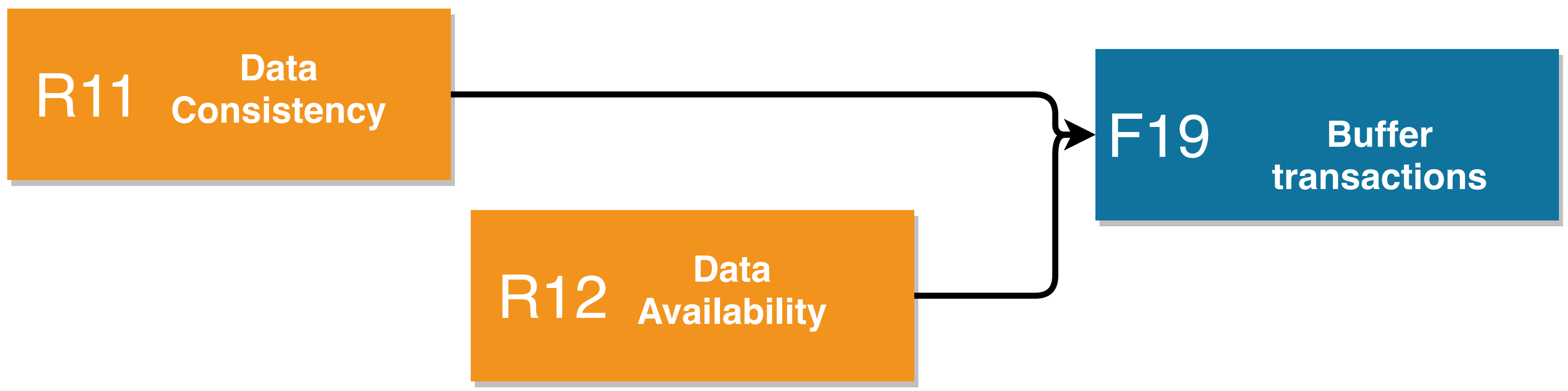

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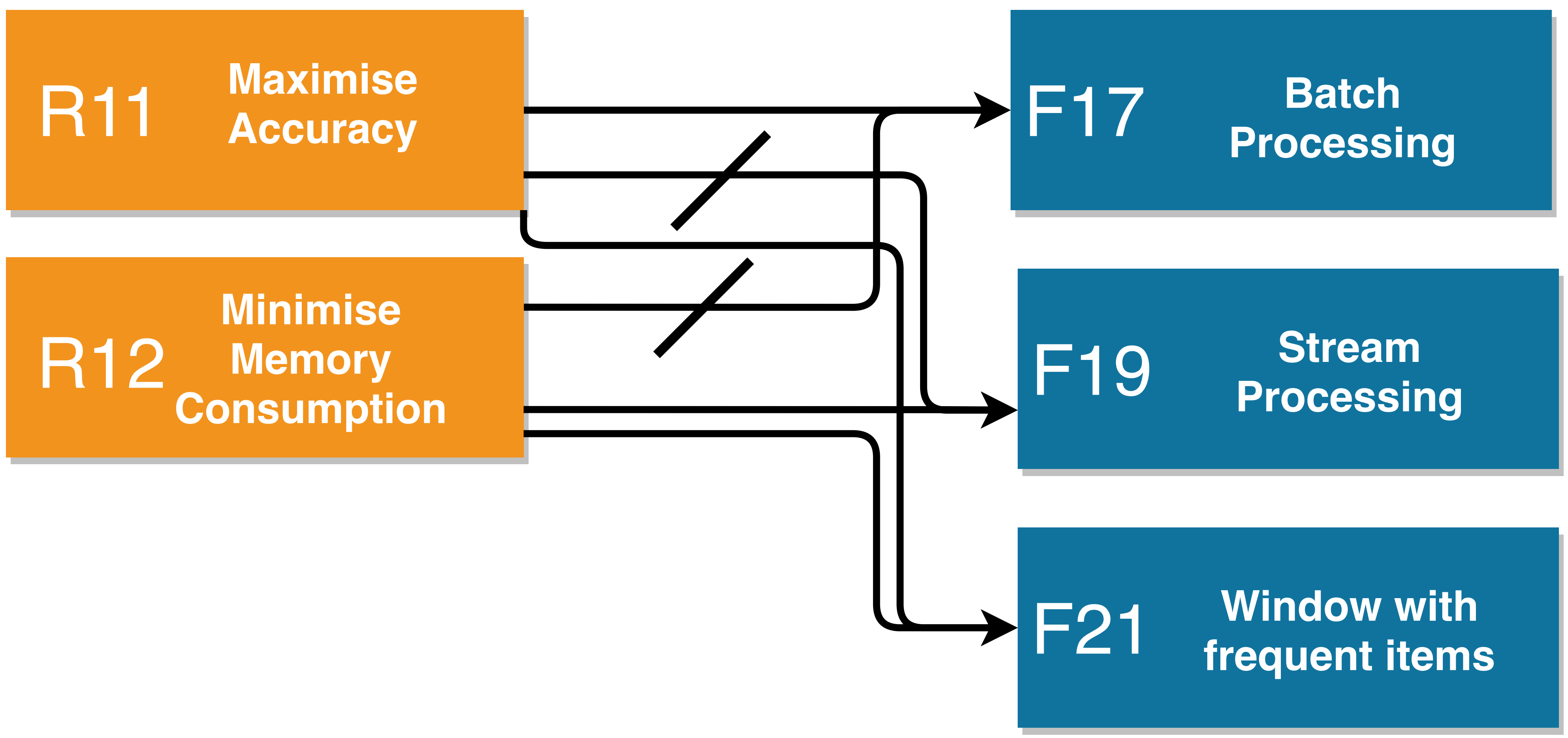

D - LESSON LEARNED

- Explicit representation of conflicts in knowledge simplify both detection and resolution
- The definition of conflicts using a priori knowledge is not alway feasible
- Partial conflicts requires a detailed understanding of the correlation between feature values

DOMAIN DEPENDENCIES

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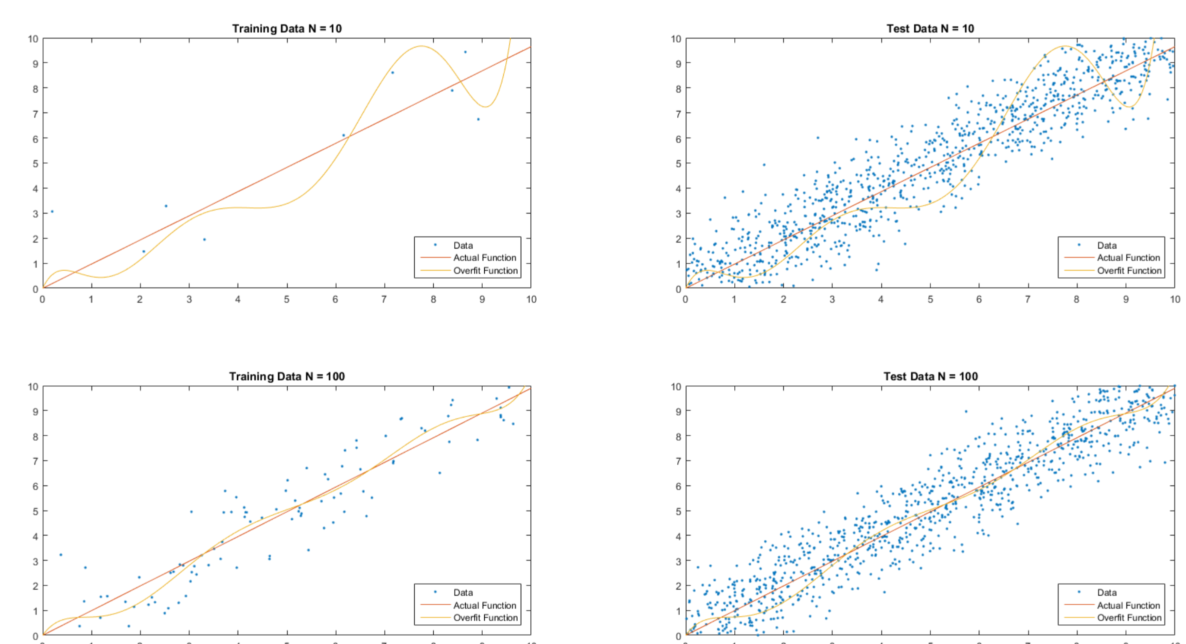
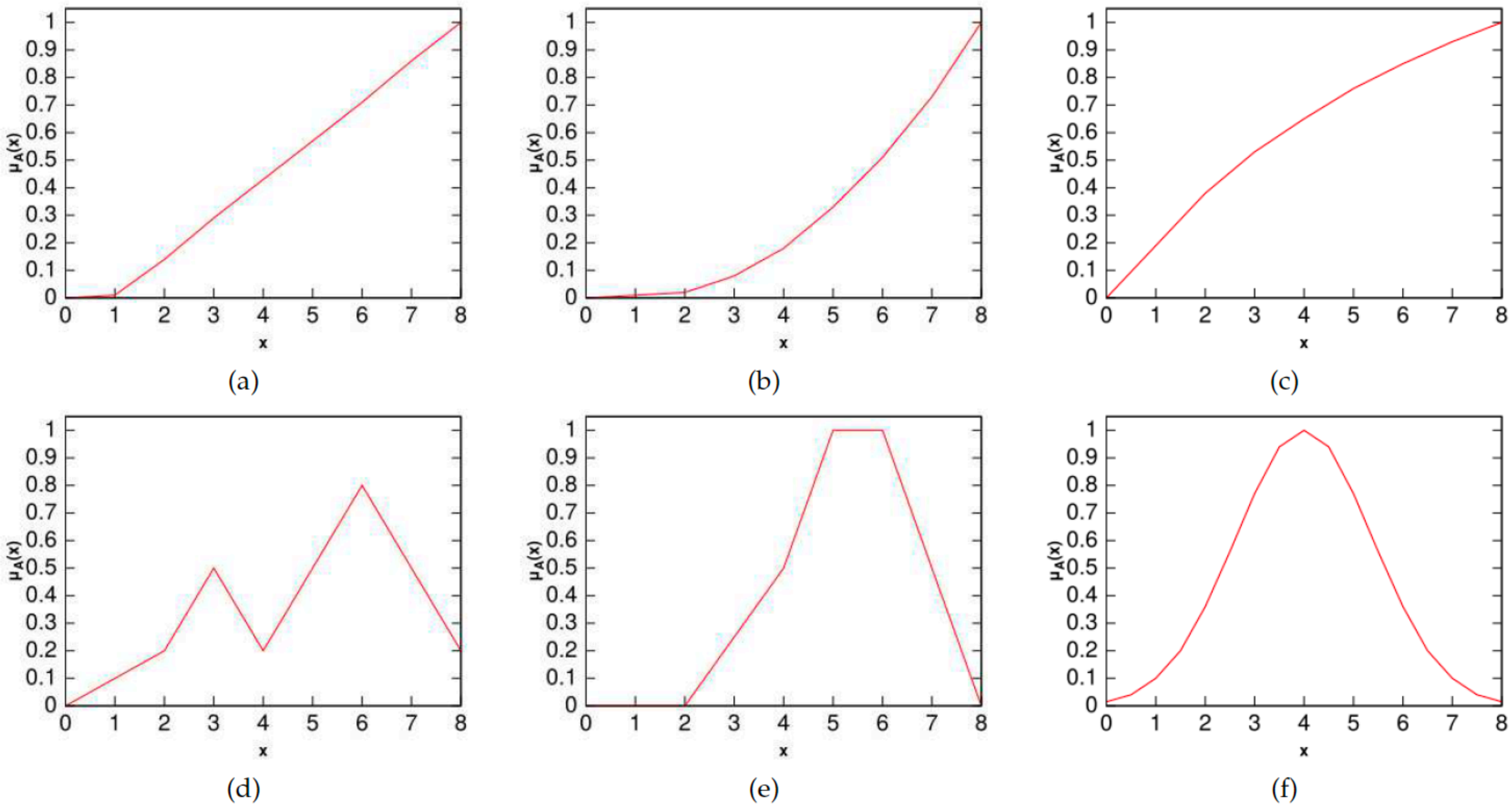
- Representing the dependency between two domains of values permits to constraints their values
  - Different scales can apply
  - Different distributions shapes can apply
  - Statistical generalisation may not apply
  - Non stationary behaviour may apply



DOMAIN DEPENDENCIES

- Fuzzy membership functions can be used to map a domain to a normalised degree of satisfaction and to put it in relationship with other domains



Ardagna, Claudio Agostino, Valerio Bellandi, Michele Bezzi, Paolo Ceravolo, Ernesto Damiani, and Cedric Hebert. "Model-based big data analytics-as-a-service: take big data to the next level." IEEE Transactions on Services Computing (2018).

DOMAIN DEPENDENCIES

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- Fuzzy membership functions can be used to map a domain to a normalised degree of satisfaction and to put it in relationship with other domains
- Using fuzzy logic the same truth function used with predicate logic can be used with domain dependency
  - $P \rightarrow \neg Q$ equivalent to $\neg P \vee \neg Q$
    - $\neg P$ equivalent to 1-P
    - $P \vee Q$ equivalent to $max(P, Q)$
  - $P \rightarrow \neg Q$ equivalent to $max(1\text{-}P, 1\text{-}Q)$

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DOMAIN DEPENDENCIES

- Given two variables A and B we can define the dependency between their domains using the following steps:
  1. Map domain D_A to a [0, 1] interval using a fuzzy MF
  2. Map domain D_B to a [0, 1] interval using a fuzzy MF
  3. The truth function $max(1\text{-}P, 1\text{-}Q)$ tell us if two values of the valuables are conflicting or not
- Example: is μ_B conflicting with μ_A given that μ_A is *0.5* and μ_B is *0.6*?

  $max(0.5, 0.4) = 0.5 \leqslant \mu_B$

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DOMAIN DEPENDENCIES

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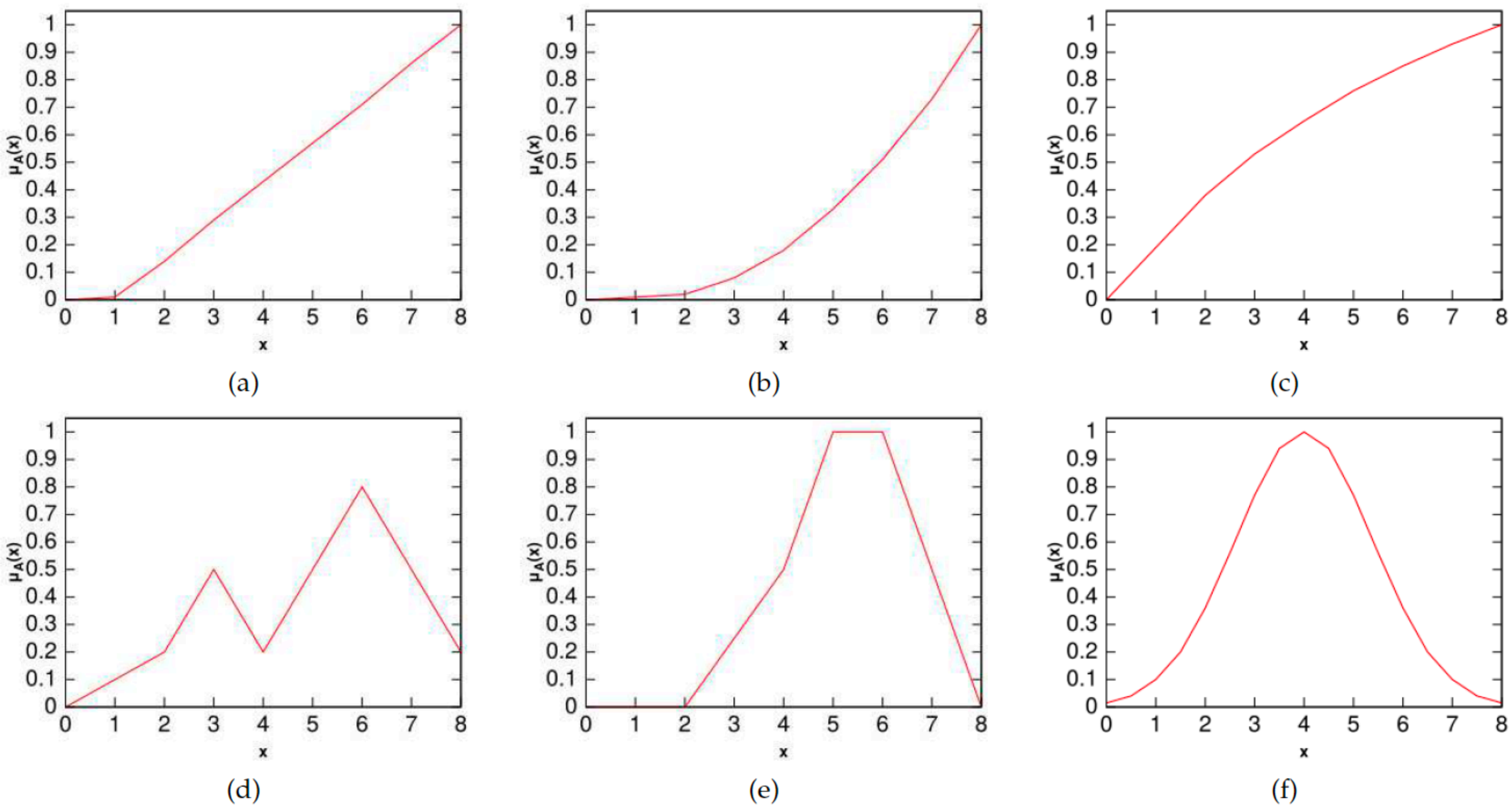
- A domain is view as the interval of values (either discrete or continue) contained in a lower limit and an upper limit
  D: [a, b]



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DOMAIN DEPENDENCIES

- A domain is view as the interval of values (either discrete or continue) contained in a lower limit and an upper limit D: [a, b]
  - a) linear and monotonic $$\mu_A(v \in \mathscr{D}) = \frac{a-v}{b-a}.$$
  - b) quadratic monotonic $$\mu_A(v \in \mathscr{D}) = \frac{(a-v)^2}{(b-a)^2}$$
  - d) triangular non-monotonic $$\mu_A(v \in D) = \begin{cases} 0, & \mathrm{v} \leq \mathrm{a} \\ \frac{v-a}{m-a}, & \mathrm{a} \leq \mathrm{v} \leq \mathrm{m} \\ \frac{b-v}{b-m}, & \mathrm{m} \leq \mathrm{v} \leq \mathrm{b} \\ 1, & \mathrm{v} \geq \mathrm{b} \end{cases}$$
  - f) gaussian non-monotonic $$\mu_A(v \in \mathscr{D}) = e^{-\frac{v-m}{2k^2}}$$

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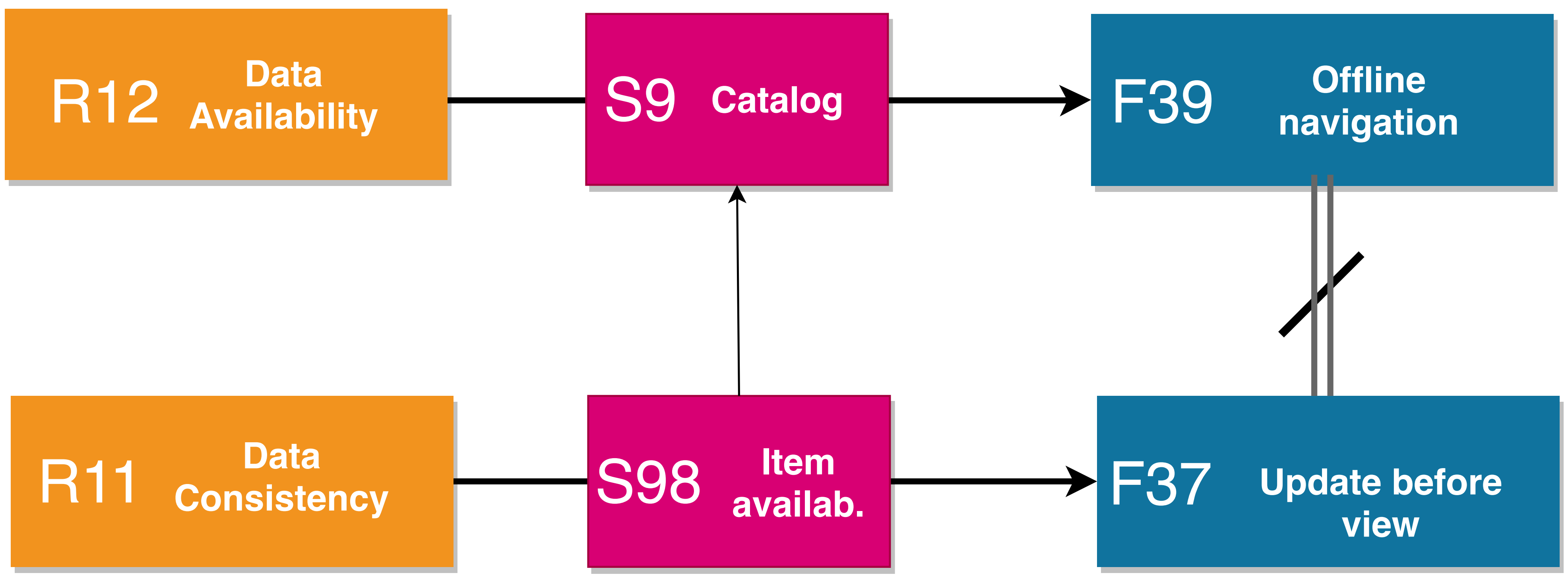
DOMAIN DEPENDENCIES

- A key point to represent dependencies between two variables' domains is studying their correlation
  - Regression analysis
  - Nonparametric regression
  - Multiple regression analysis
  - Random forest
  - Neural networks

Marquez, Leorey, Tim Hill, Reginald Worthley, and William Remus. "Neural network models as an alternative to regression." In Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences, vol. 4, pp. 129-135. IEEE, 1991.

EXAMPLE 4 – CONFLICTING DEPENDENCIES FOR KR



DD – LESSON LEARNED

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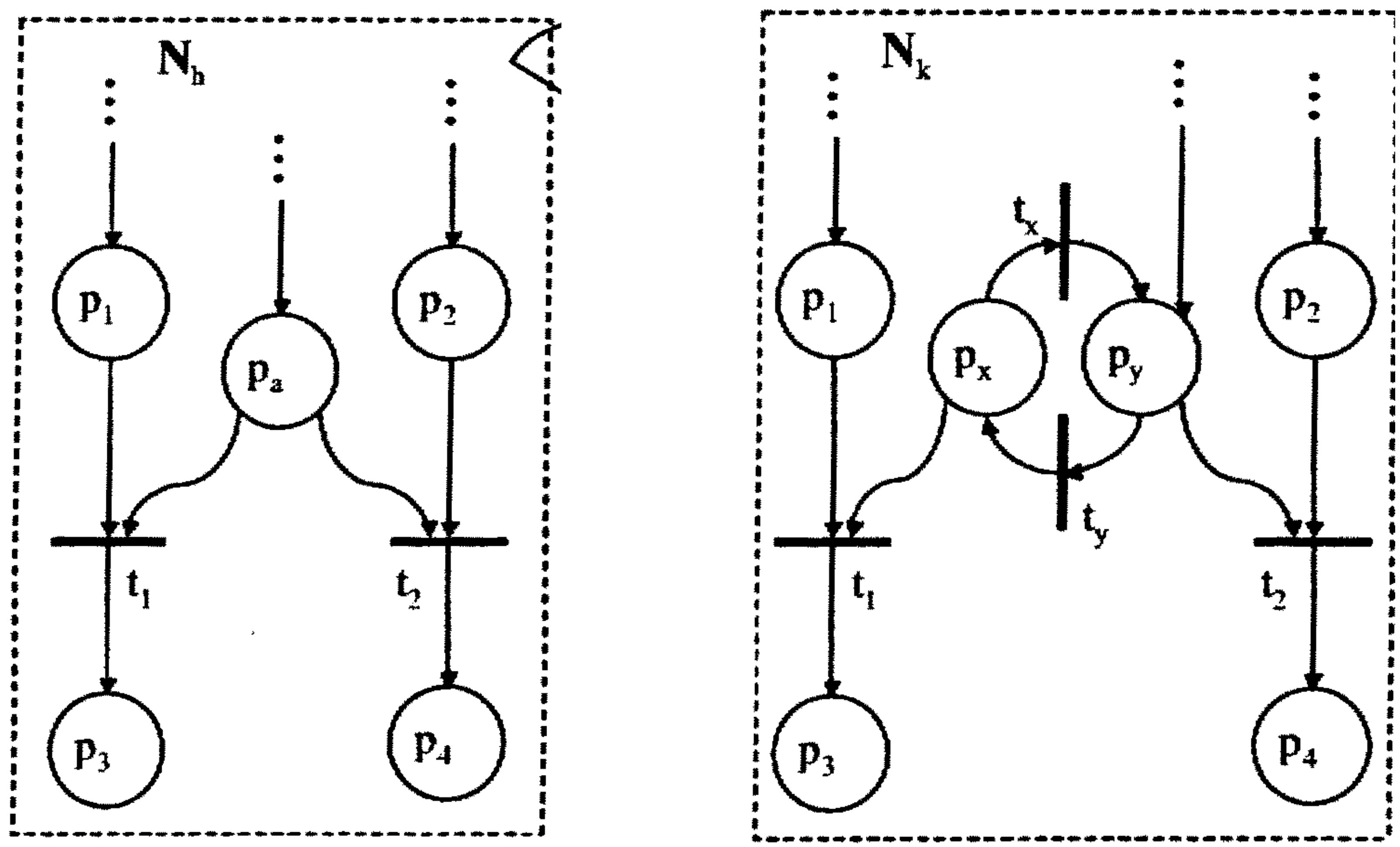
- Explicit representation of conflicts in knowledge simplify both detection and resolution
- The definition of conflicts using a priori knowledge is not alway feasible
- Partial conflicts requires a detailed understanding of the correlation between feature values
- In dynamic systems conflicts

  may arise from concurrency

DYNAMIC SYSTEMS

- If a resource can be used by mutually exclusive access only, conflicts can be addressed by resource sharing
    - Concurrency must be represented and handled



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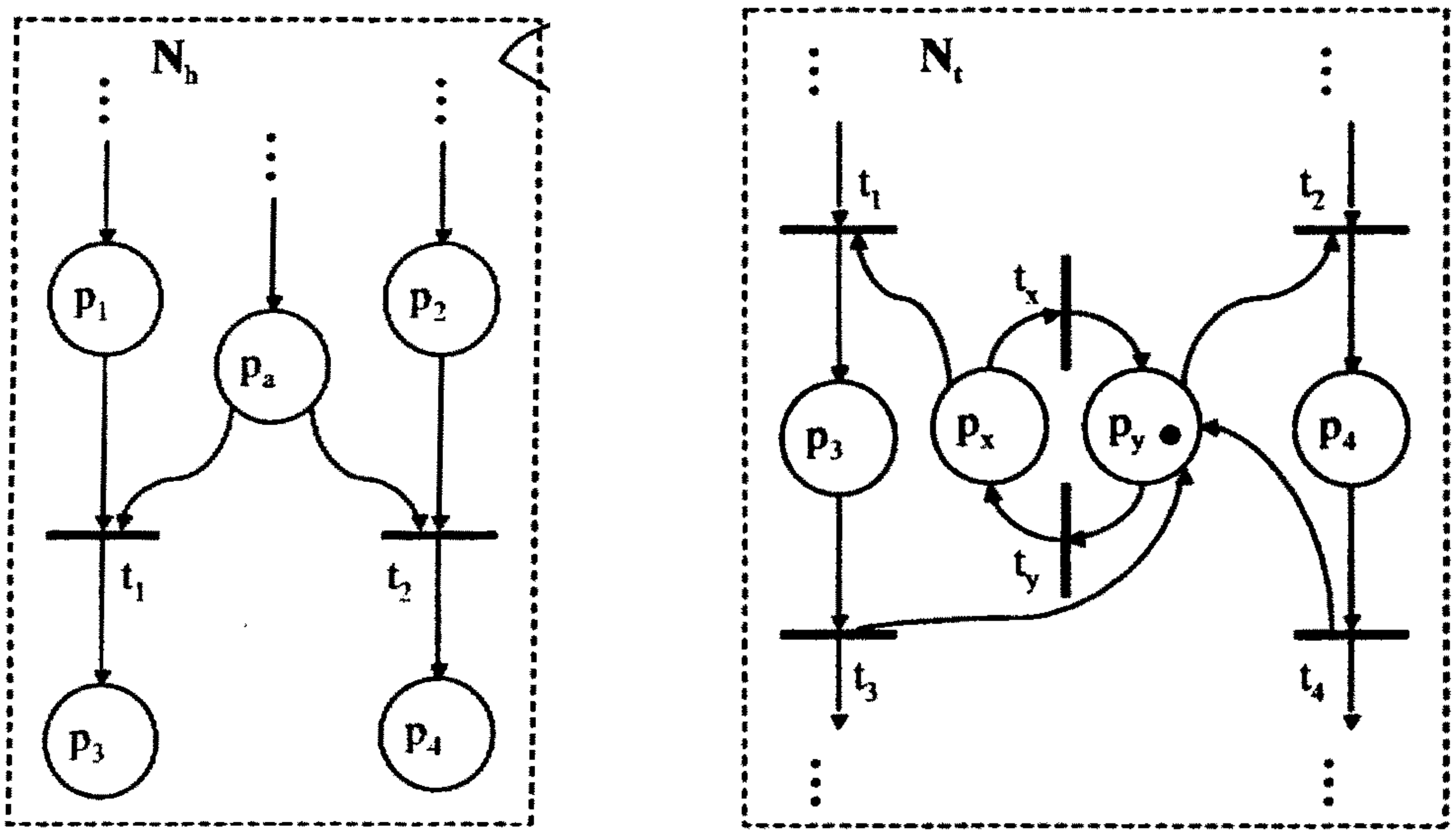

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DS – LESSON LEARNED

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- Explicit representation of conflicts in knowledge simplify both detection and resolution
- The definition of conflicts using a priori knowledge is not alway feasible
- Partial conflicts requires a detailed understanding of the correlation between feature values
- In dynamic systems conflicts may arise from concurrency
- Resources may be consumed after a number of accesses

IN SUMMARY

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	Knowledge Representation	Dependencies		Dynamic Systems
Detect	Aligment	Manual Tagging	Detect Correlation	Discovery
	*	**	**	**
Resolve	Partitioning	Priorities Specificity	Domain Mapping	Reachability
Predicates	**	**	*	*
Dis & Cont Variables	*	*	**	*
Concurrency				**
Factual Impossible				

MOTIVATIONS

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	Knowledge Representation	Dependencies		Dynamic Systems
Detect	Aligment	Manual Tagging	Detect Correlation	Discovery
	More inconsistencies that needed	May implies incompleteness	Data may be incom. Concept Drift applies	Multiple models
Resolve	Partitioning	Priorities Specificity	Domain Mapping	Reachability
Predicates	Well with priorities	Well with priorities and specificity	Overcomplicated	Overcomplicated
Dis & Cont Variables	You have to accept possibility	You have to accept possibility	Well if the mapping is appropriate	Limited to what can be expressed by tokens
Concurrency				Well
Factual Impossible	Nope	Nope	Nope	Nope

Thank You

HANDLING CONFLICTING REQUIREMENTS

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