Maintenance of case bases: current algorithms after fifty years

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50years

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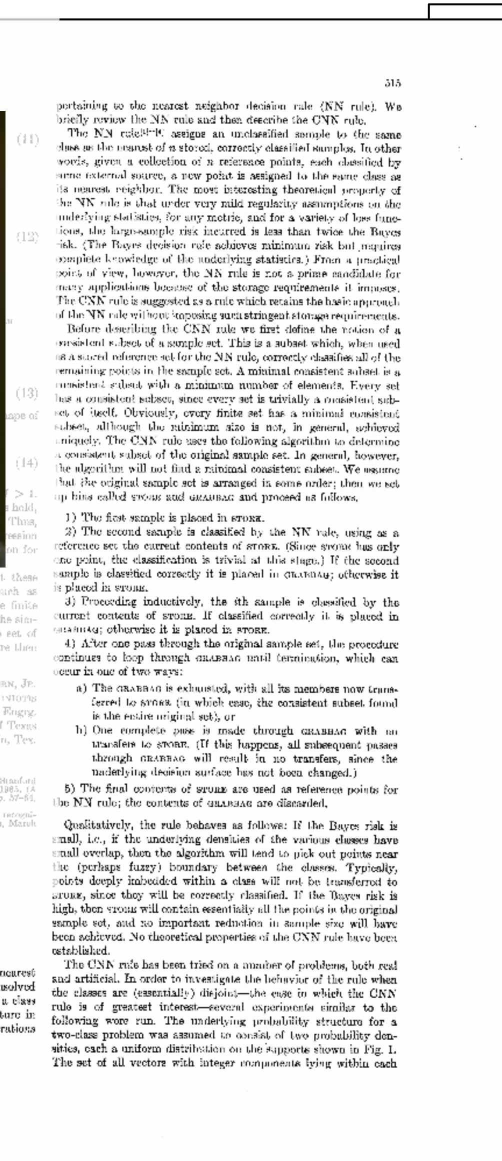
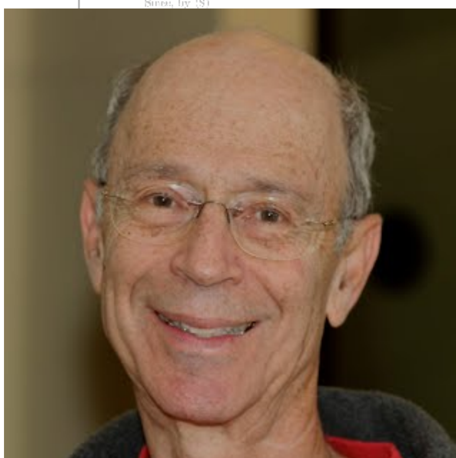
"The Condensed Nearest Neighbor Rule," IEEE Trans. on Information Theory, Vol. IT-14, No. 3, pp 515-516 (May 1968)

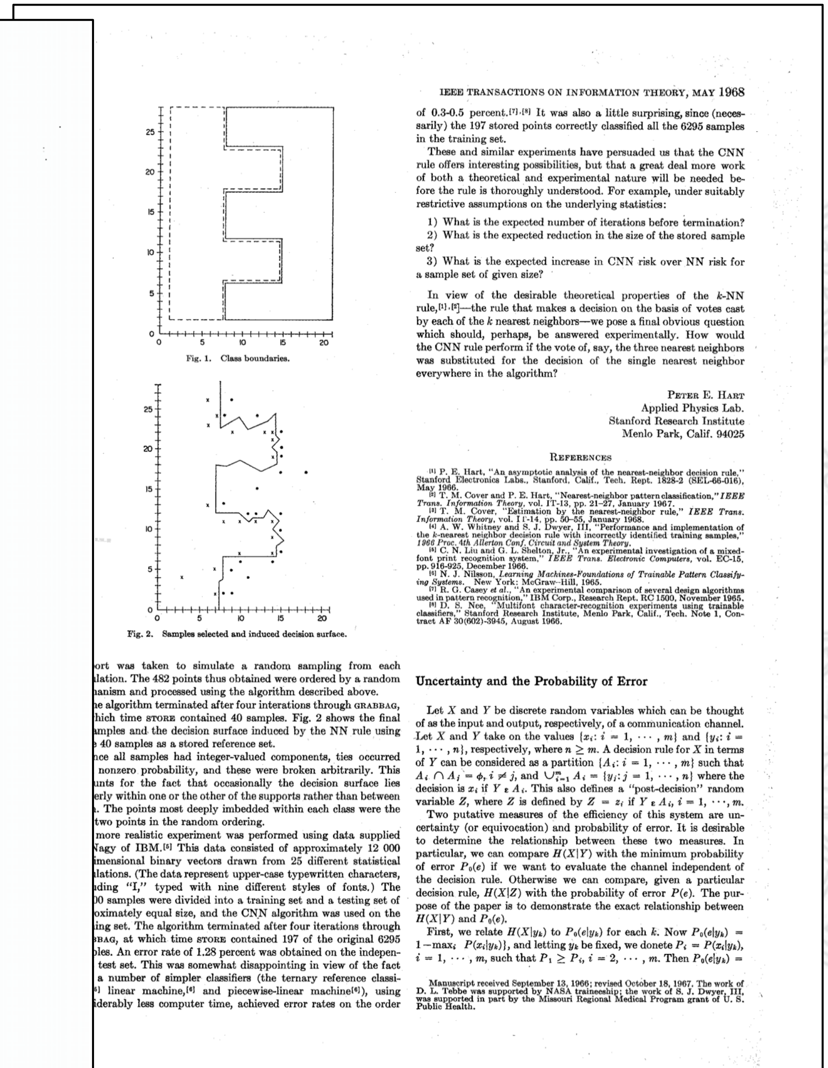


CORRESPONDENCE 515

The Condensed Nearest Neighbor Rule



Peter E. Hart
CNN algorithm



IEEE TRANSACTIONS ON INFORMATION THEORY, MAY 1968

Fig. 1. Class boundaries.

Fig. 2. Samples selected and induced decision surface.

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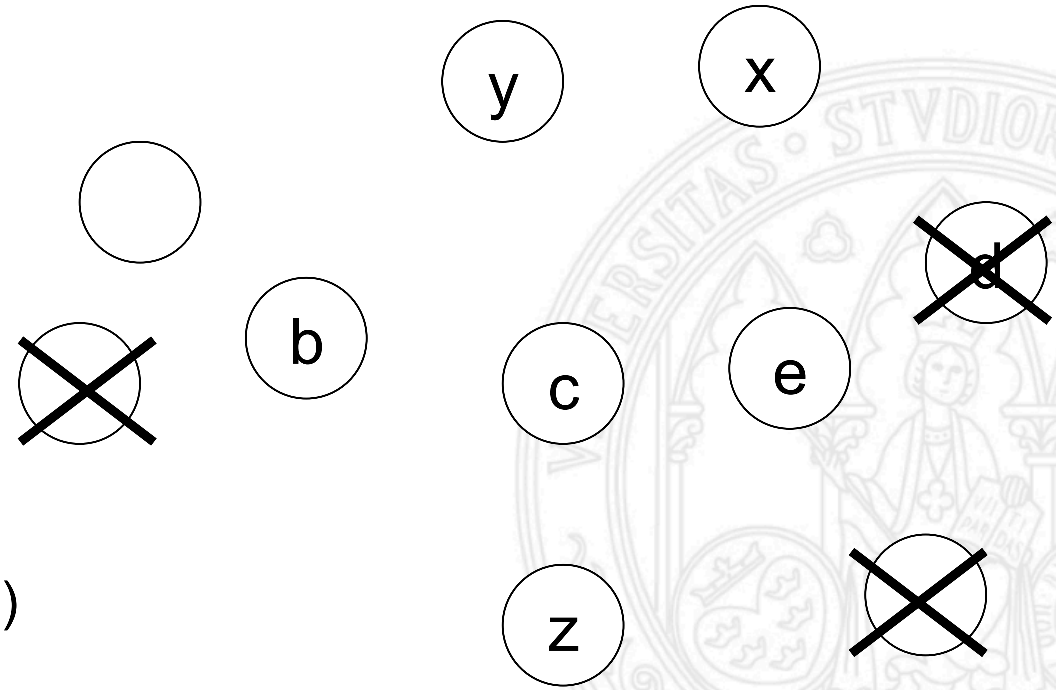
Uncertainty and the Probability of Error

Picture from:
https://sites.google.com/a/peterhart.net/peterhart/Home

"The Condensed Nearest Neighbor Rule," IEEE Trans. on Information Theory, Vol. IT-14, No. 3, pp 515-516 (May 1968)

CNN Algorithm

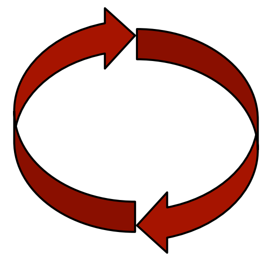
```
Input: original case-base C
Output: maintained case-base CM
    CM← empty
    c← first case of C
    C← C – {c}
    CM← CM U {c}
    Repeat
      For all c in C
        C← C – {c}
        if not CorrecClassifyNN(c,CM)
            CM← CM U {c}
        endif
      enfor
    Until C without changes
    Return CM
```



- **OUTLINE:**

1. 50 years map of CBM algorithms
2. Advances last 5 years
3. Conclusions

- **CASE-BASED REASONING (CBR)**
  - Solves by retrieving similar problems (cases)
    - Retrieve, Adapt, Learn



  - ≠ model-based systems
    - No structure: atomic **case** = (problem, solution)
    - **Case Base**: Knowledge incremented **dynamically**
  - Challenge: number of cases
  - Approach: Case-Base **Maintenance** (CBM) alg.

- **50 years CBM map**

NN period

1968	1972	1972	1975	1976	1976	1987	1991	1995	1997	1997-2000
CNN	RNN	ENN	SNN	RENN	All-KNN	SHRINK	IB1 IB2 IB3 IB4	Competence Def.	Introsp. Learn	DROP 1 2 3 4 5
Hart	Gates	Gates	Ritter et al	Tomek	Tomek	Kibler-Aha	Aha-Kibler	Smyth-Keane	Bonzano et al	Wilson-Martinez

B. Smyth and E. McKenna. *Competence models and the maintenance problem*. Computational Intelligence, 17(2): 235-249, 2001.

!= Machine Learning: purpose of each case in CBR

COMPETENCE: capacity of each case to solve

- Coverage
- Reachability
- Competence Groups

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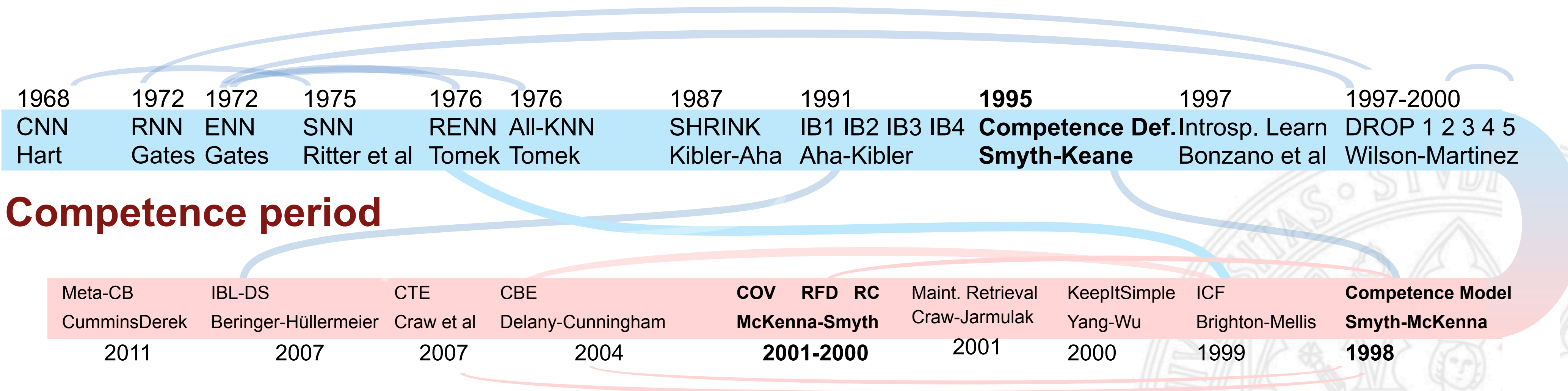
• 50 years CBM map

NN period



- **OUTLINE:**

1. 50 years map of CBM algorithms
2. **Advances last 5 years**
3. Conclusions

- **Last 5 years**
  - Intense research
  - Novel (theoretical) models
  - New problems (non existing)
  - Real life solutions

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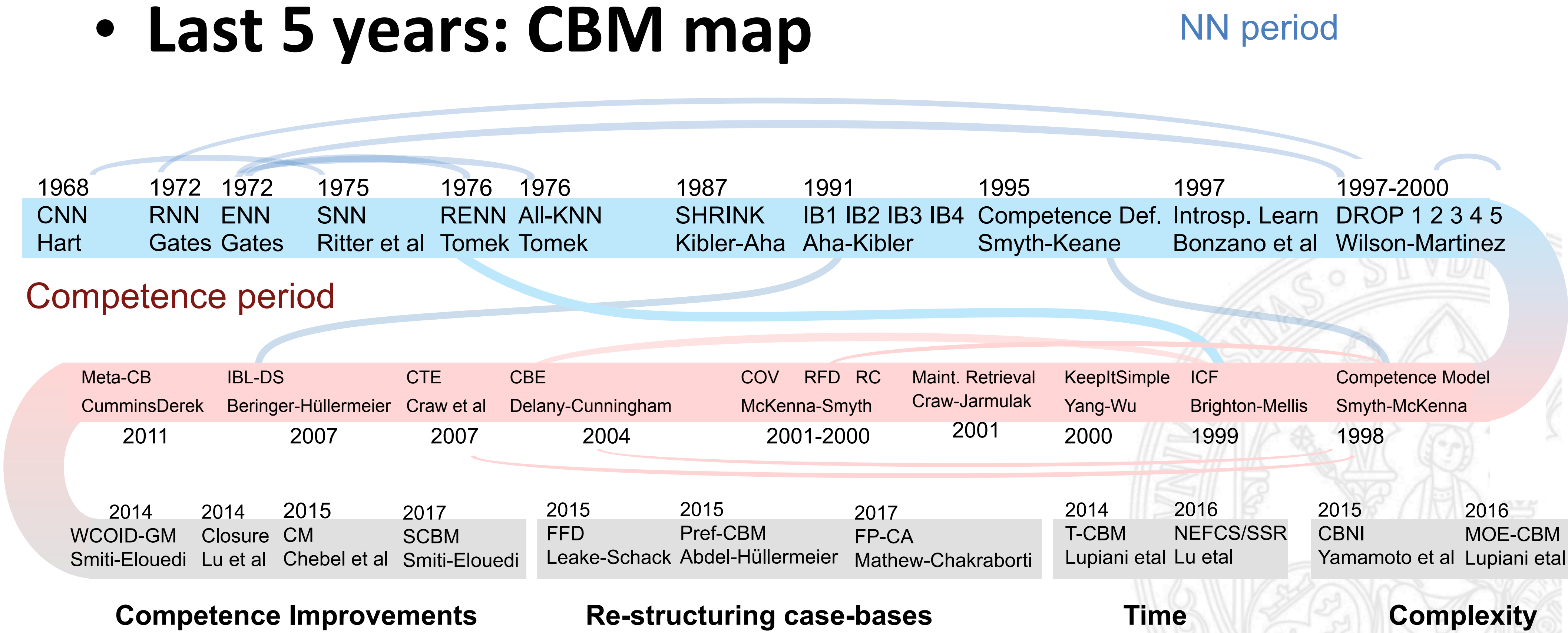
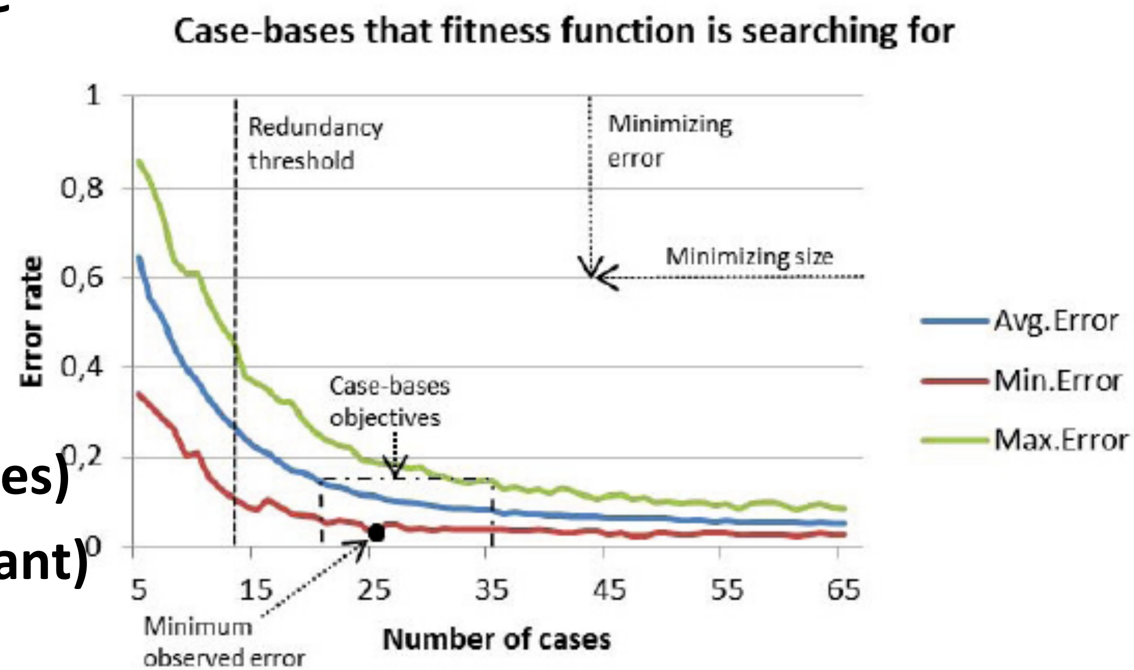
• Last 5 years: CBM map



Period 2014-2018

- **Last 5 years: complex problems**
  - **Multi-objective optimization**
    - **Search Space: Case-Base**
    - **Size vs. Accuracy**
    - **Noise vs. Redundancy**
    - **MOEA: NSGA-II**
    - **Optimization:**
      - **Min(no redundant cases)**
      - **Min(dist. Non-redundant)**
      - **Max(accuracy system)**

MOE-CBM Lupiani-Massie-Craw et al 2016

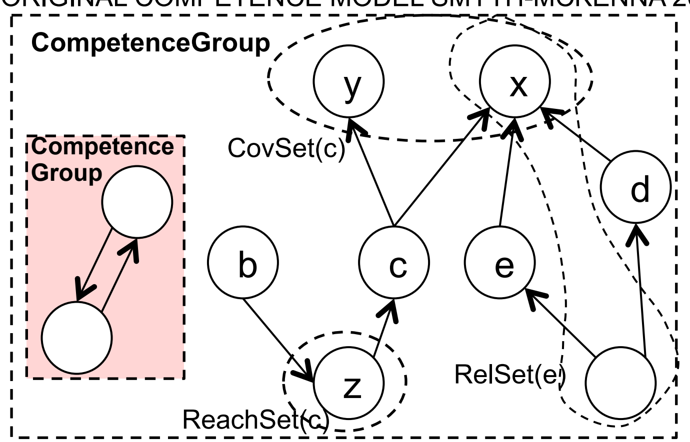


E.Lupiani, S.Massie, S.Craw, J.M. Juarez, and J. Palma. Case-base maintenance with multi-objective evolutionary algorithms. Journal of Intelligent Information Systems, 46(2):259–284, Apr 2016..

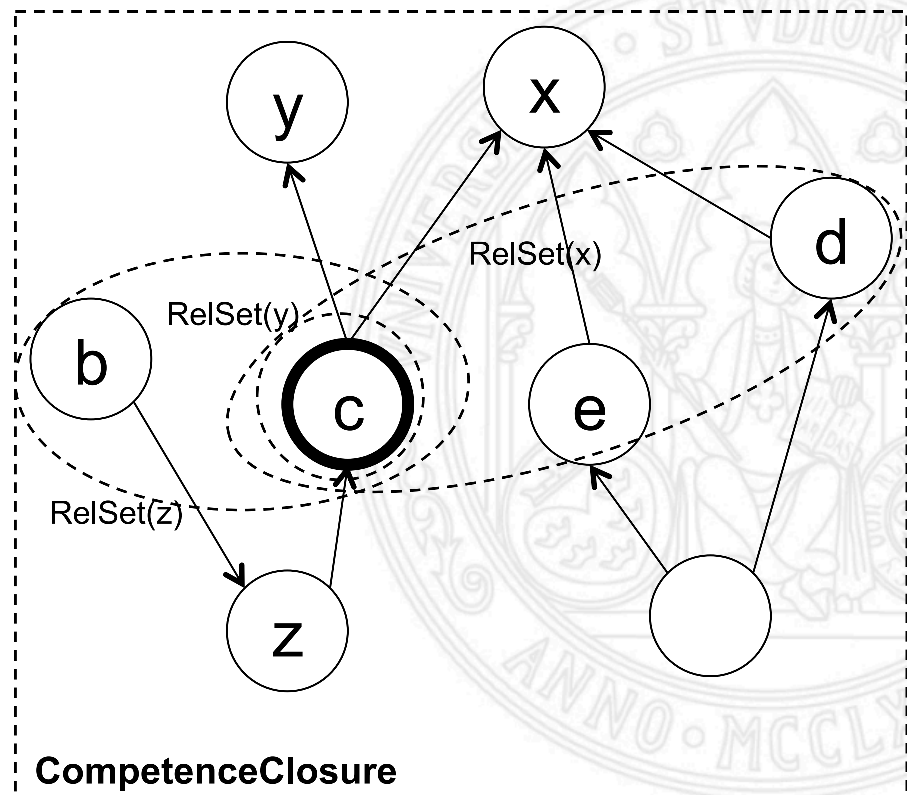
- **Last 5 years: improving competence**
  - **Closure-Competence Model**
    - **Inadequate Comp. Model**
    - **Disjoint partitions (consistent)**

$$CompetenceClosure(G) \iff \forall c, c' \in G, \; \exists\, SharedCoveragePath(c, c') \;\wedge\; \Big(\forall c_k \in C - G, \; \nexists c \in G \;:\; SharedCoverage(c_k, c) \Big)$$

ORIGINAL COMPETENCE MODEL SMYTH-MCKENNA 2011



Lu-Zhang-Lu Competence Model Proposal 2014



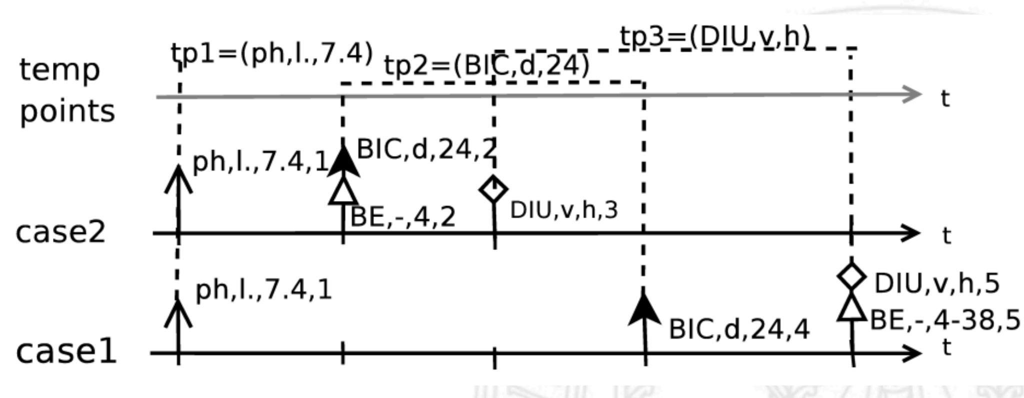
RelClosure(c)=RelSet(x) U RelSet(y) U RelSet(z)

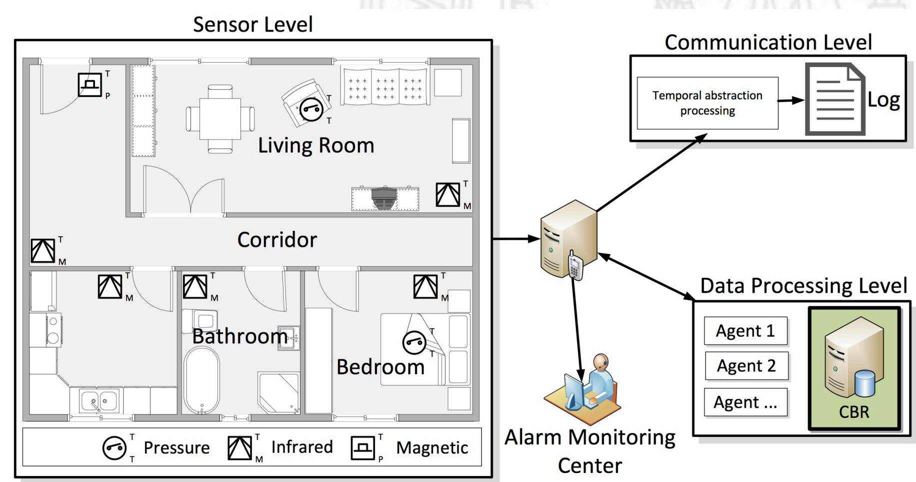
Competence closure and Related closure example

Ning Lu, Guangquan Zhang, and Jie Lu. *Concept drift detection via competence models. Artificial Intelligence*, 209:11–28, April 2014.

- **Last 5 years: temporal dimension (real life problems)**
  - **Temporal CBM**
    - **Case: sequence of events**
    - **Adapt CBM approaches**

T-CBM Lupiani-Juarez-Palma 2014

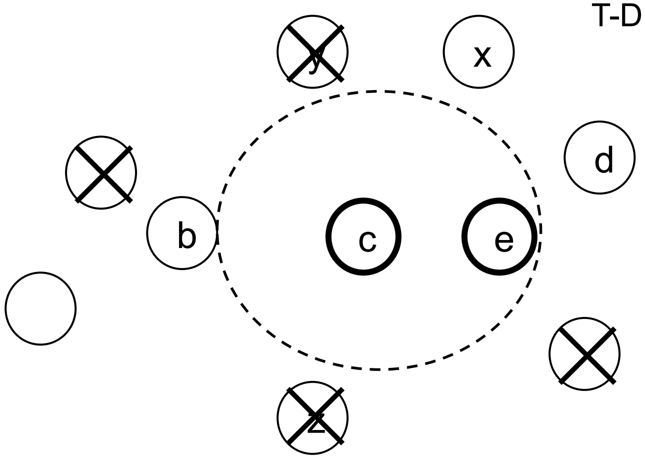




Monitoring Elderly People At Home: falling detection

TEMPORAL MAINTENANCE:

T-CNN
T-RENN
T-DROP1-3
T-ICF
Etc.



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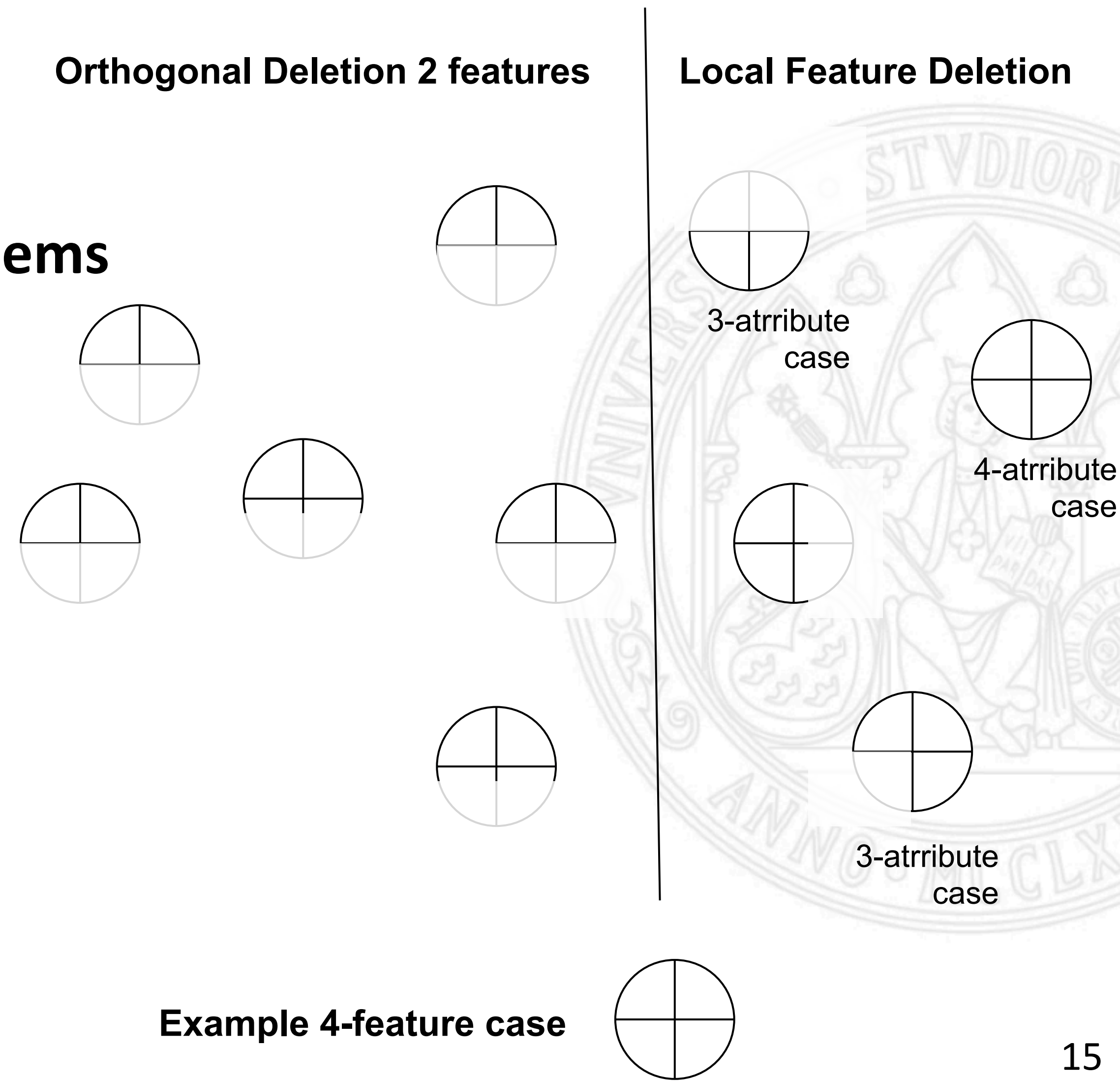
- **Last 5 years: re-structuring case-bases**
  - **Flexible Feature Deletion**
    - **Remove part case**
    - **Less competence loss**
    - **High dimensional problems**

FFD Leak-Schack, 2015



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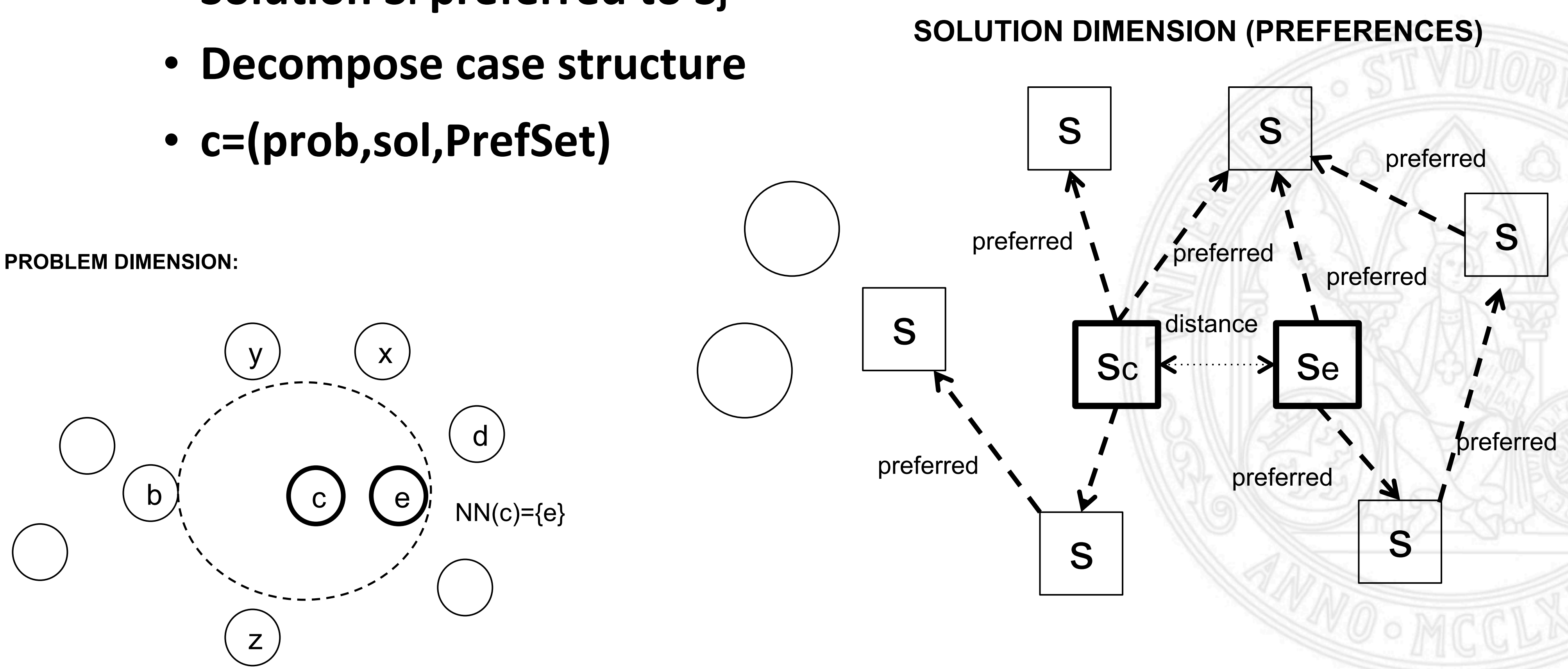
- **Last 5 years: re-structuring case-bases**
  - **Preference CBR Model**
    - **Solution Si preferred to Sj**
    - **Decompose case structure**
    - **c=(prob,sol,PrefSet)**

Pref-CBR approach Abdel-Aziz & Hüllermeier, 2015



A. Abdel-Aziz and E. Hüllermeier. Case base maintenance in preference based CBR. In Eyke Hüllermeier and Mirjam Minor, editors, Case-Based Reasoning Research and Development, pages 1–14. Springer, 2015..

Example Pref-CBM approach

- **OUTLINE:**

  1. 50 years map of CBM algorithms
  2. Advances last 5 years
  3. **Conclusions**

- **Conclusions**
  - **Deep Impact of Competence Model Smyth-McKenna-Keane**
  - **New potential CBR applications (not explored in depth):**
    - **Interpretable reduction of high dimensional problems: e.g. Flexible Feature Deletion[Leake&Schack,2015]**
    - **Social network datasets: e.g. Compositional Adaptation [Mathew&Chakraborti,2017]**
  - **Applications in the Industry:**
    - **Monitoring: T-CBM [Lupiani et al 2015]**
    - **Long term use of intelligent systems: Drift-CBM [Lu et al 2016]**
  - **Future directions:**
    - **Fair comparisons (now limited to classical CBM alg.)**

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