(Im)Possibilities of Predicate Detection in Crash-Affected Systems using Interrupt-Style Failure Detectors

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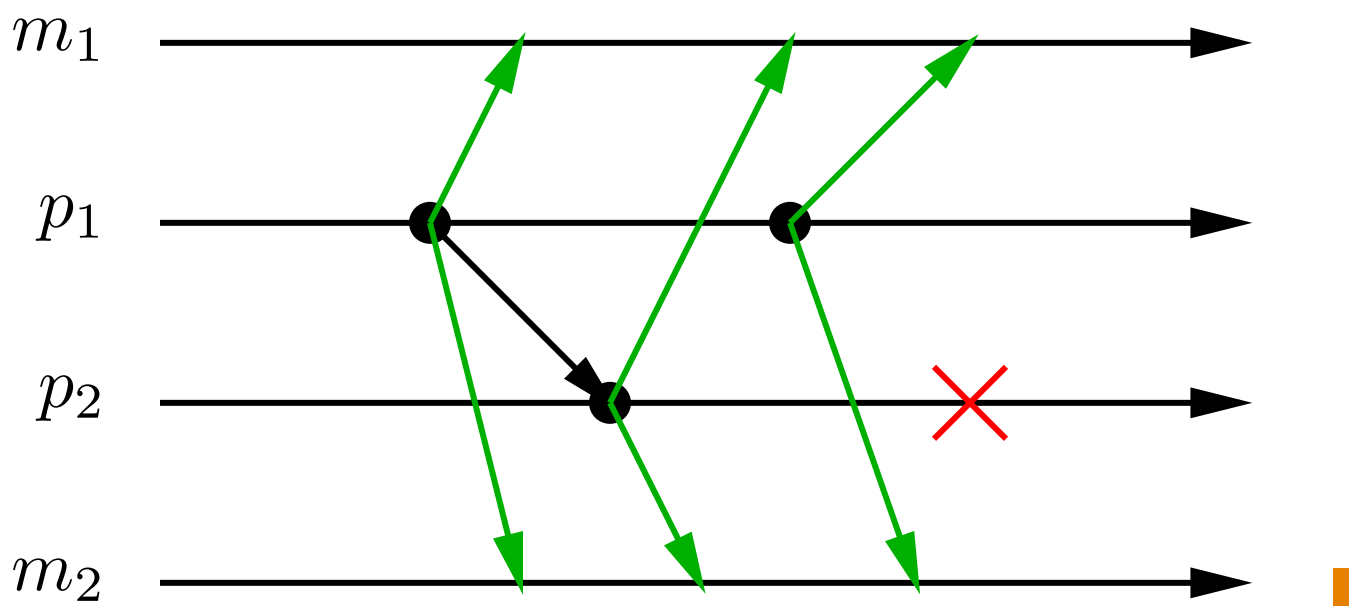
Predicate Detection



- Does a global predicate φ hold throughout the computation?

Predicate Detection Semantics

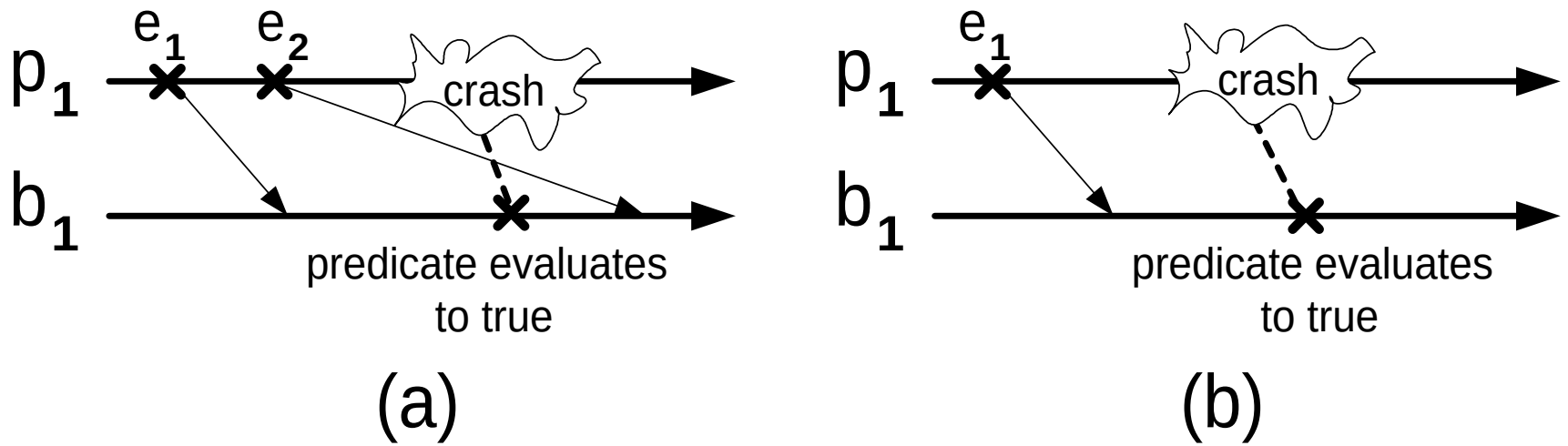
- Perfect predicate detection Sem_1:
  - (S) If the algorithm triggers a detection, then φ has held in the computation.
  - (L) If φ holds, then the algorithm will eventually trigger a detection.
- Stabilizing predicate detection Sem_2:
  - L and $\Diamond S$.
- Infinitely often accurate predicate detection Sem_3:
  - L and $\Box\Diamond S$.

Focus

- Which predicate detection semantics are achievable in asynchronous systems where crash faults can happen?
- Use asynchronous systems augmented with (unreliable) failure detectors.
- Relevant failure detector classes:
  - Perfect $\mathcal{P}$ and eventually perfect $\Diamond\mathcal{P}$ [CT96].
  - Infinitely often accurate $\Box\Diamond\mathcal{P}$ [GM98].

Most interesting Result

- $\mathcal{P}$ not sufficient for perfect predicate detection.



Types of Failure Detectors

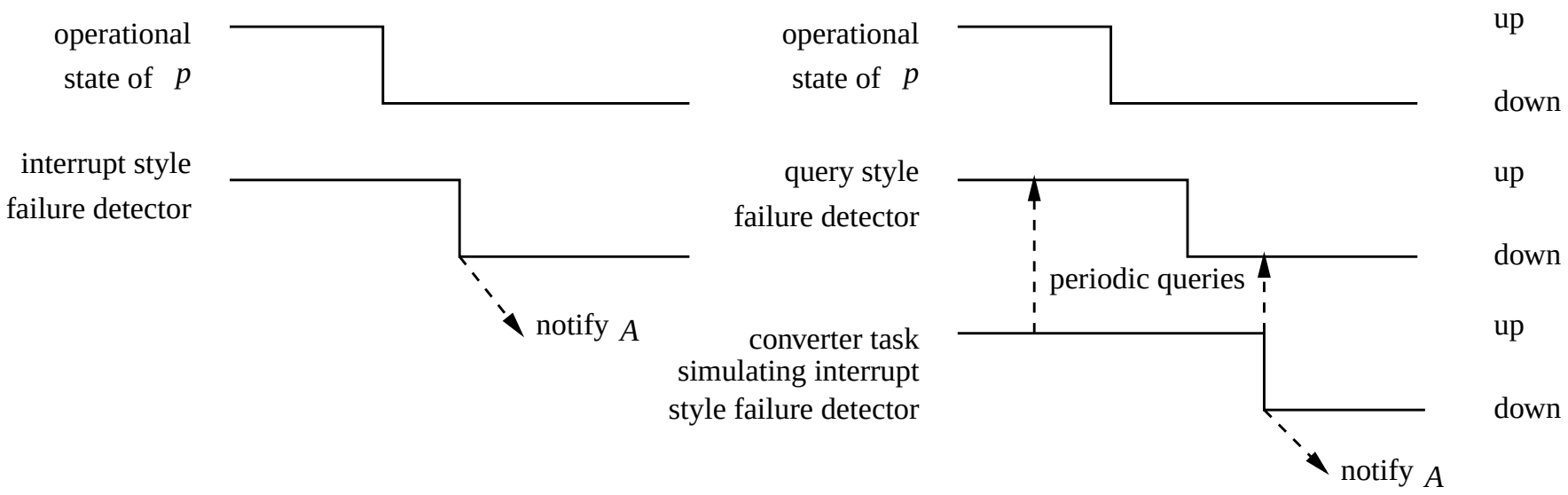
- QM – Query model (Chandra and Toueg [CT96]): Query-style failure detectors.
  - Spurious detections can go unnoticed.
- IM – Interrupt model (Garg and Mitchell [GM98]): Interrupt-style failure detectors.
  - Every detection reaches application.
- We use interrupt-style ones.

Solvability of Problems

- If a problem P is solvable using $\mathcal{D}$ in QM, then P is solvable in IM.
  - Proof idea: IM is more restrictive.
- Vice versa? (P solvable in IM $\Rightarrow$ P solvable in QM.)
- Only for $\mathcal{D} \in \mathcal{P}$ or $\Diamond\mathcal{P}$, not for $\mathcal{D} \in \Box\Diamond\mathcal{P}$.

Proof Idea

- Use converter task which regularly queries failure detector.



(IM) (QM)

Summary

- Predicate detection in crash-affected systems.
- Which predicate detection semantics are achievable using which types of failure detectors?
- Must go for stabilizing predicate detection semantics in many practical settings.
- Interesting aspect: IM vs. QM.
- For more details see WSS paper [GP01a] and IBM Research Report [GP01b] for full proofs.

Acknowledgements

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References

[CT96] Tushar Deepak Chandra and Sam Toueg. Unreliable failure detectors for reliable distributed systems. *Journal of the ACM*, 43(2):225–267, March 1996.

[GM98] Vijay K. Garg and J. Roger Mitchell. Distributed predicate detection in a faulty environment. In *Proceedings of the 18th IEEE International Conference on Distributed Computing Systems (ICDCS98)*, 1998.

[GP01a] Felix C. Gärtner and Stefan Pleisch. (Im)Possibilities of predicate detection in crash-affected systems. In *Proceedings of the 5th Workshop*

on Self-Stabilizing Systems (WSS 2001), Lecture Notes in Computer Science, Lisbon, Portugal, October 2001. Springer-Verlag. to appear.

[GP01b] Felix C. Gärtner and Stefan Pleisch. (Im)Possibilities of predicate detection in crash-affected systems. Research Report RZ 3361 (# 93407), IBM Research Laboratory, Zurich, August 2001.