NC STATE UNIVERSITY Computer Science

NetApp

Google

AGILE: Elastic distributed resource scaling for Infrastructure-as-a-Service

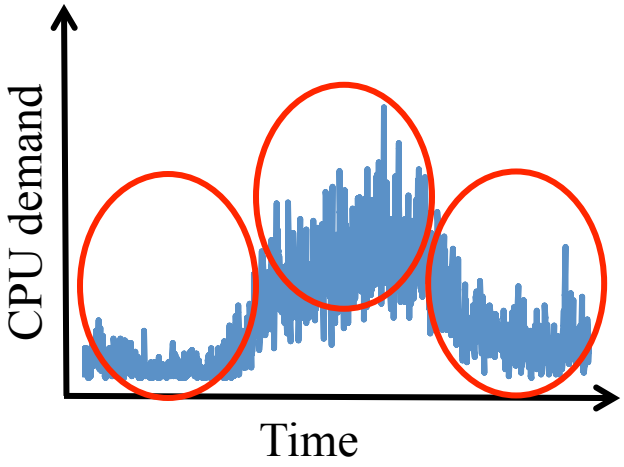
Hiep Nguyen, Zhiming Shen, Xiaohui (Helen) Gu
North Carolina State University

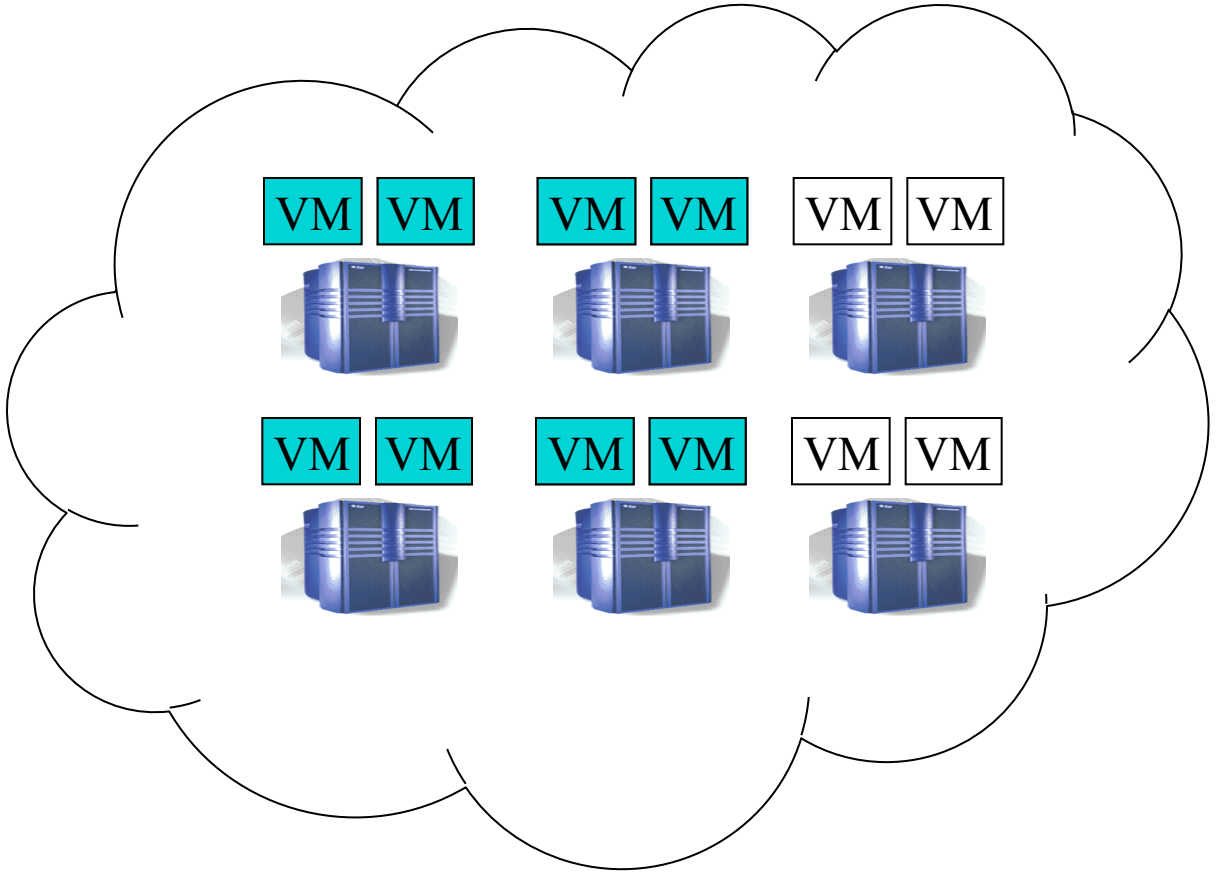
Sethuraman Subbiah
NetApp

John Wilkes
Google

Elastic resource scaling for Infrastructure-as-a-Service

- Elasticity: grow/shrink resource as required





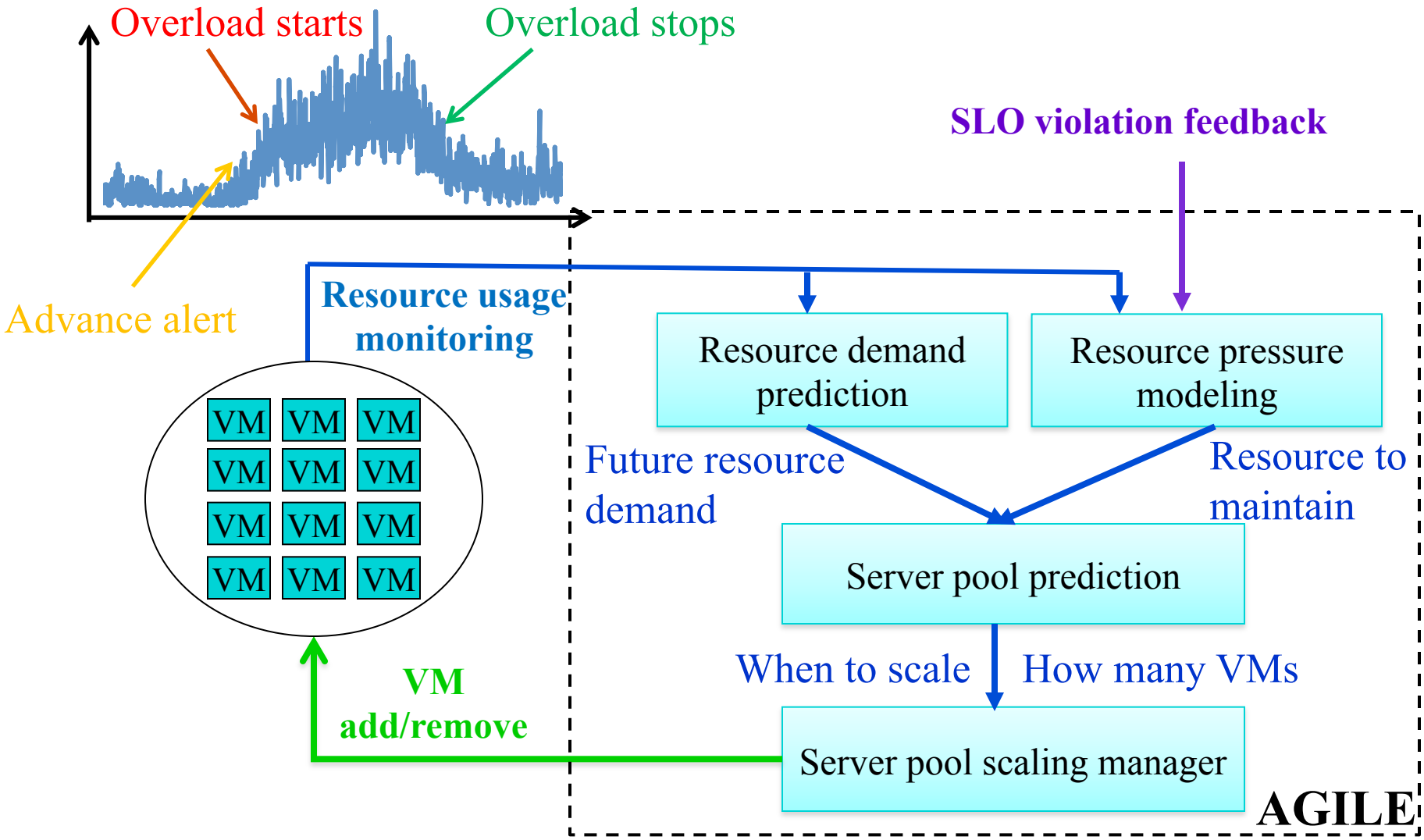
Design goals

- Application agnostic
  - Easy to deploy
  - Support different applications
- Effective overload handling
  - Predict overload accurately
  - Minimize SLO violations
  - Minimize resource cost
- Low overhead
  - Light-weight
  - Little interference

State of the art

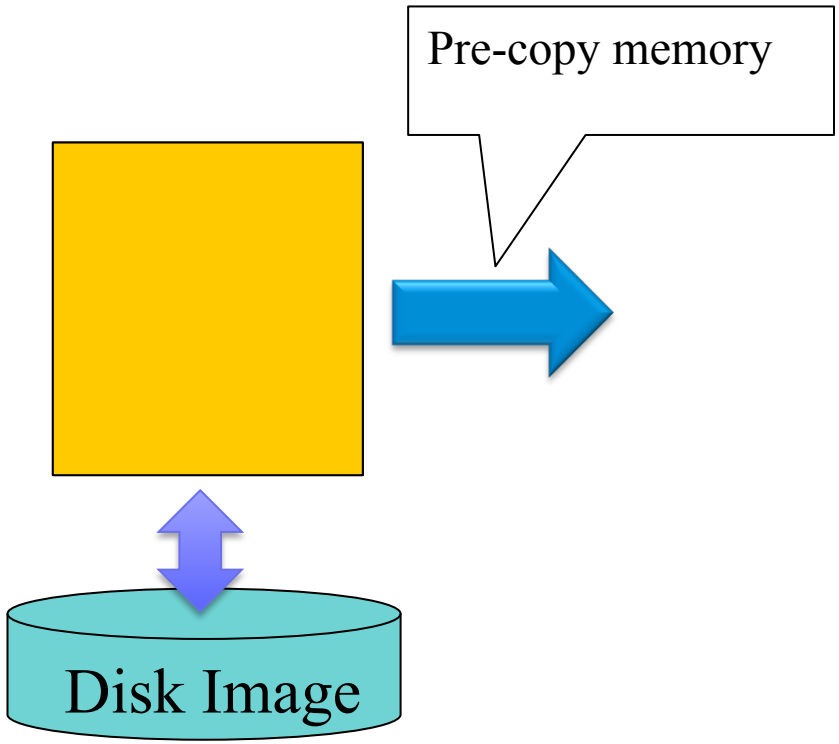
- Reactive resource scaling [e.g., Amazon EC2]
  - Performance degradation due to long instantiation latency (≈ 2 minutes)
- Trace-driven resource scaling [e.g., Chandra et al. IWQoS 2003, Gong et al. CNSM 2007, Shen et al. SOCC 2011]
  - Focus on short-term prediction or need to assume cyclic workload patterns
- Model-driven resource scaling [e.g., Zhu et al. ICAC 2008, Kalyvianaki et al. ICAC 2009, Padala et al. Eurosys 2007]
  - Have parameters that need to be specified or tuned offline for different applications/workloads

AGILE system overview



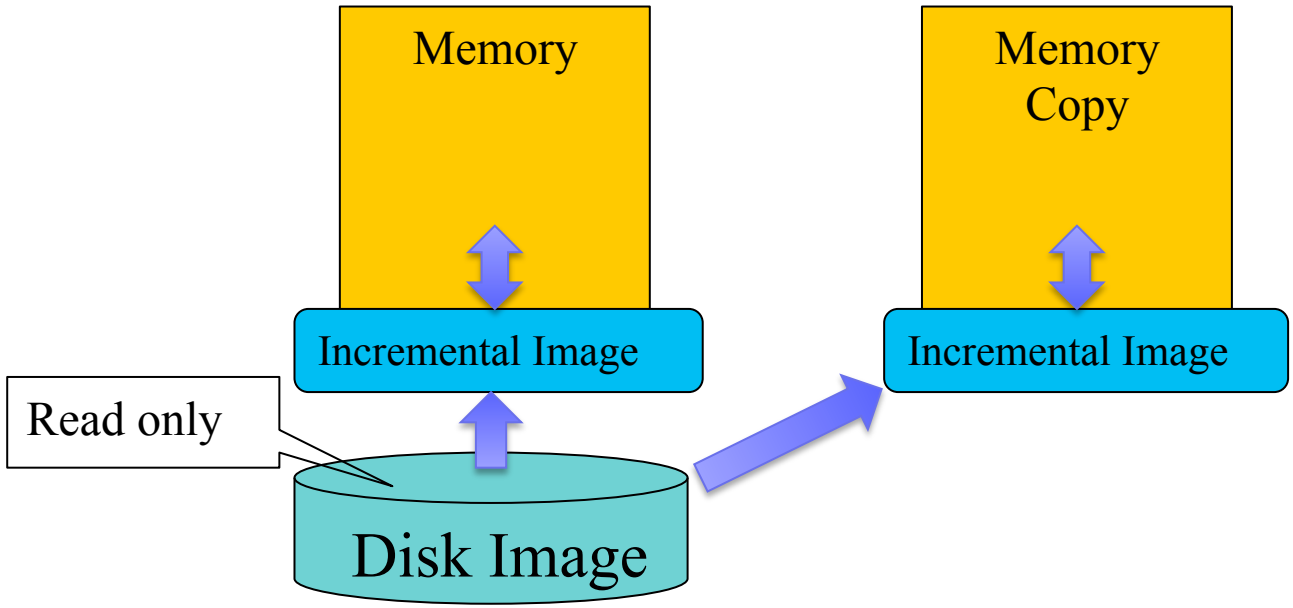
Pre-copy live VM cloning

- Design goals
  - Immediate performance scale-up
  - Avoid storing and maintaining VM snapshots



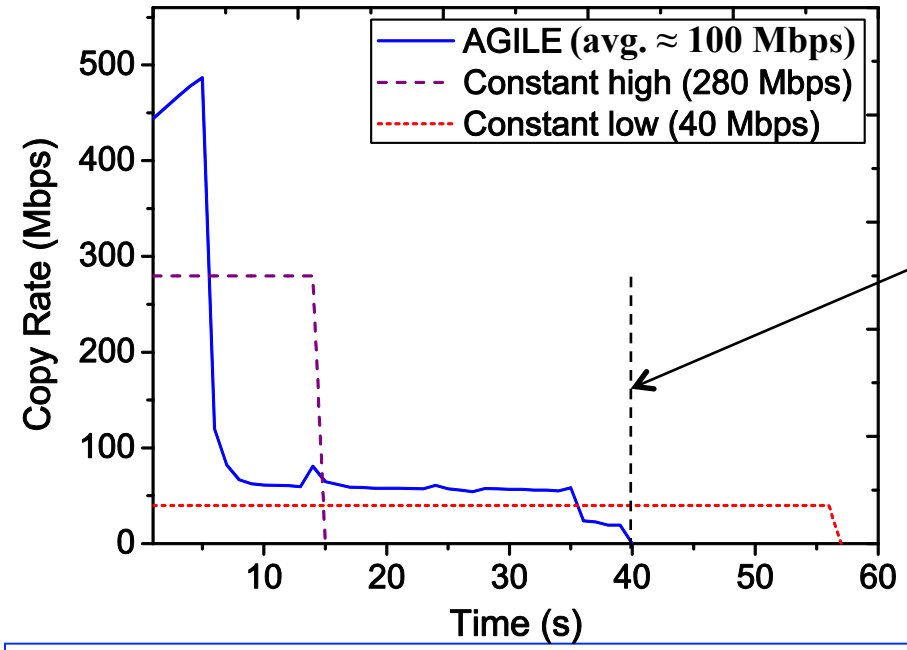
Pre-copy live VM cloning

- Design goals
  - Immediate performance scale-up
  - Avoid storing and maintaining VM snapshots



Pre-copy live VM cloning

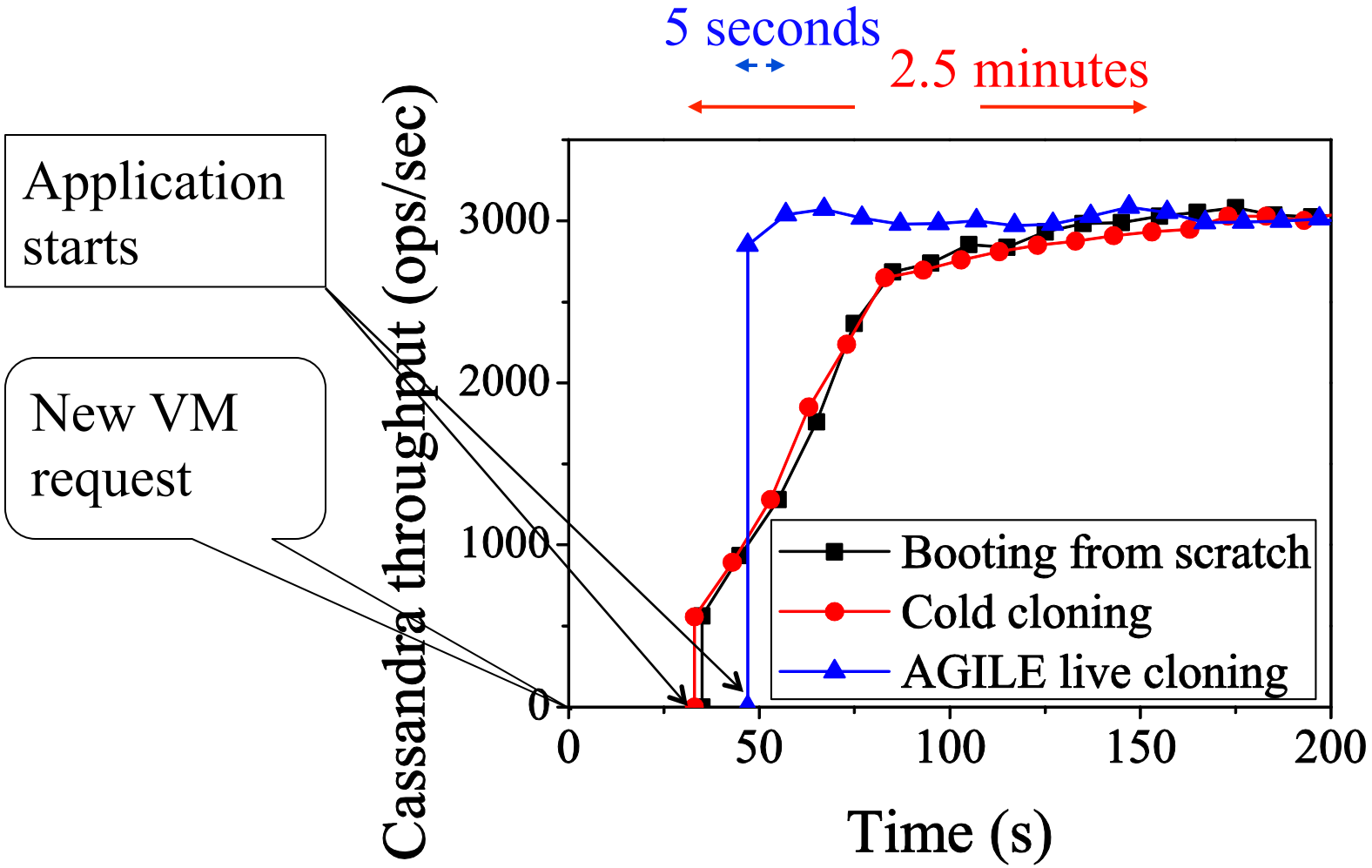
- Dynamic copy-rate configuration
  - Minimum copy-rate (e.g., little interference)
  - Finish cloning within the overload pending time



Predicted overload

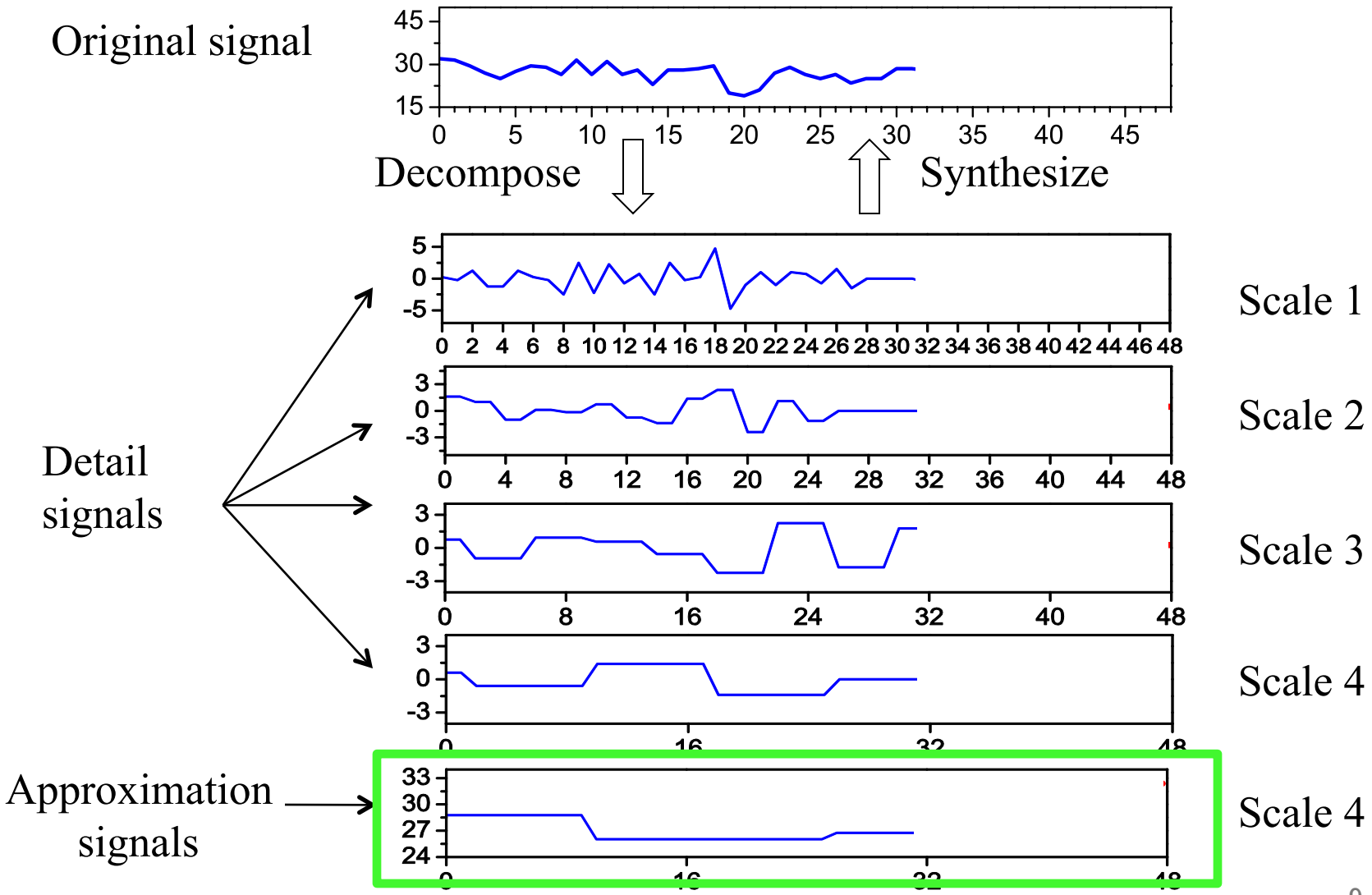
$$CopyRate = MemorySize / t_{clone} + r_{dirty}$$

Performance scale-up comparison



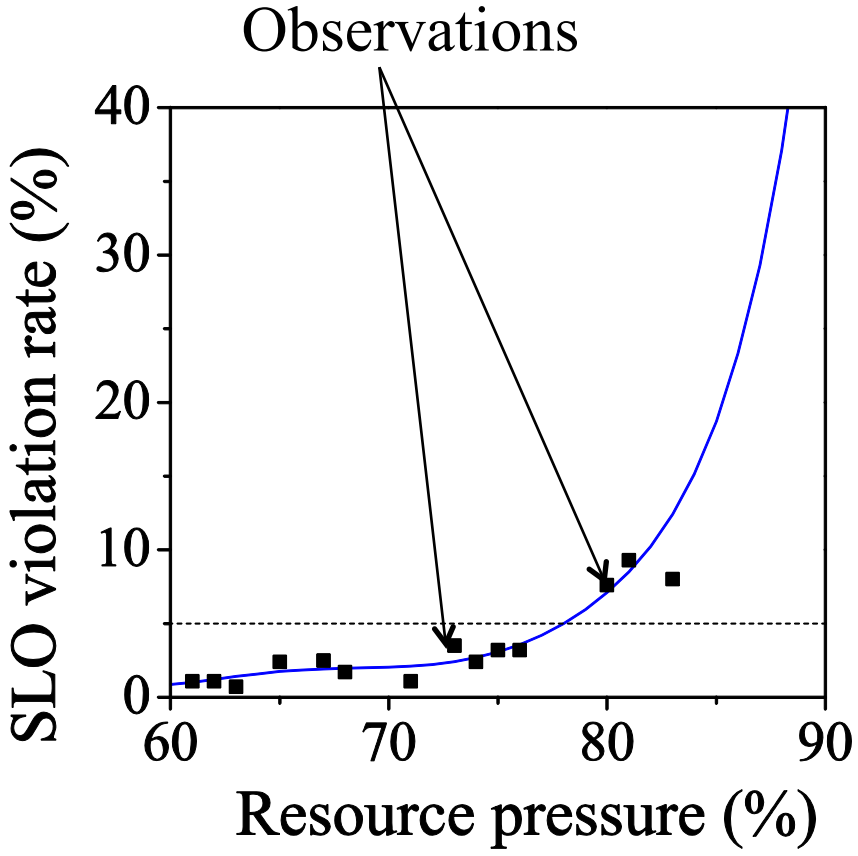
Immediate performance scale-up

Wavelet-based medium-term prediction



Online resource pressure modeling

- Mapping function between:
  - Resource pressure
  - SLO violation rate



Optimizations for AGILE cloning

- Post-cloning auto-configuration
  - Event driven auto-configuration
  - Application VMs can subscribe to critical events

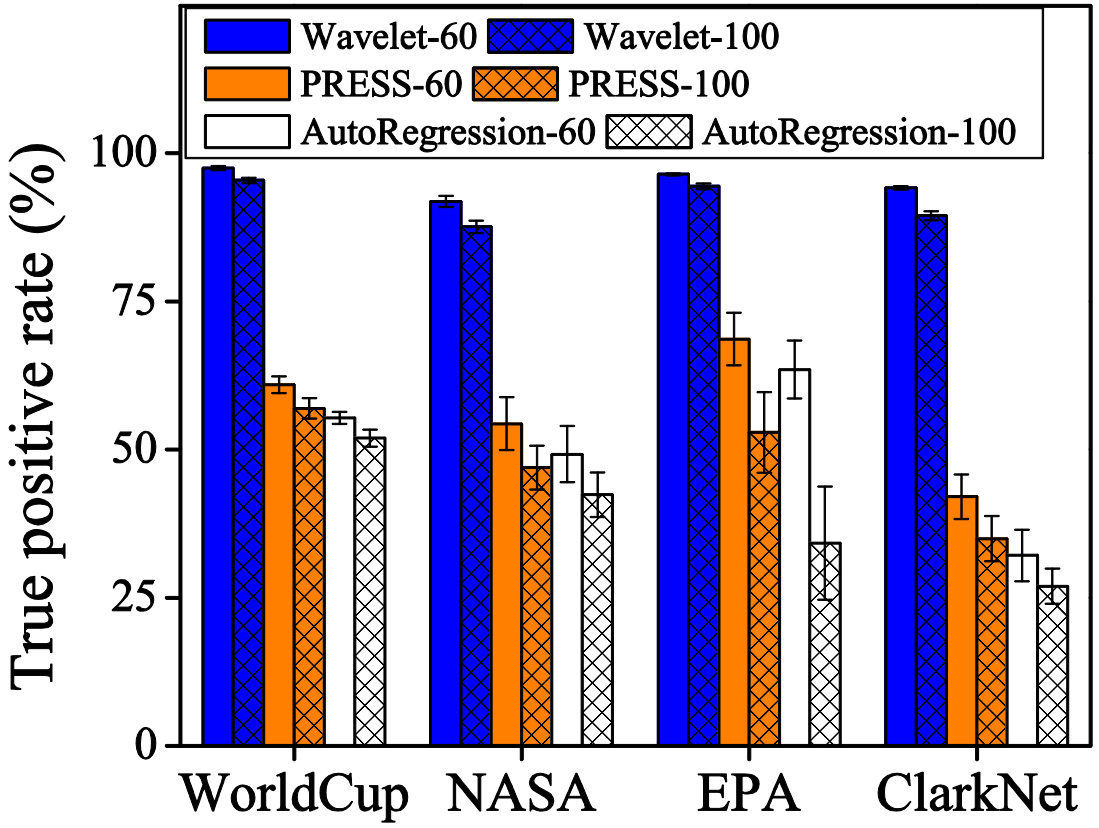
- False alarm handling
  - Continuously check predicted overload state
  - Cancel cloning triggered by the false alarm

Experimental evaluation

- Implemented on top of KVM
  - Modified KVM to support pre-copy live cloning
- Test bed:
  - 10 cloud nodes running CentOS 6.2 with KVM 0.12.1.2
- Benchmark systems
  - RUBiS driven by four real workload traces
    - WorldCup' 98, EPA, Nasa, ClarkNet (one day traces)
  - Google cluster data: 100 CPU usage and 100 Memory usage traces (29 days)

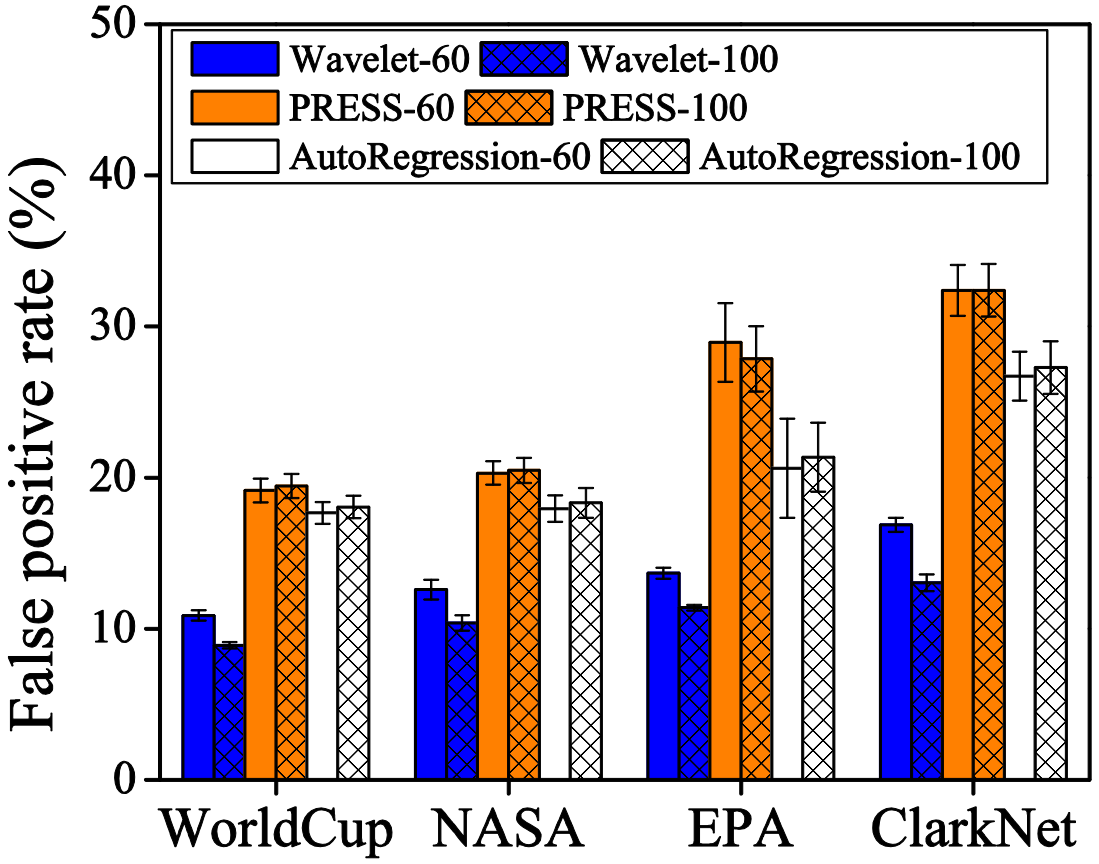
Wavelet-based prediction accuracy

- RUBiS traces



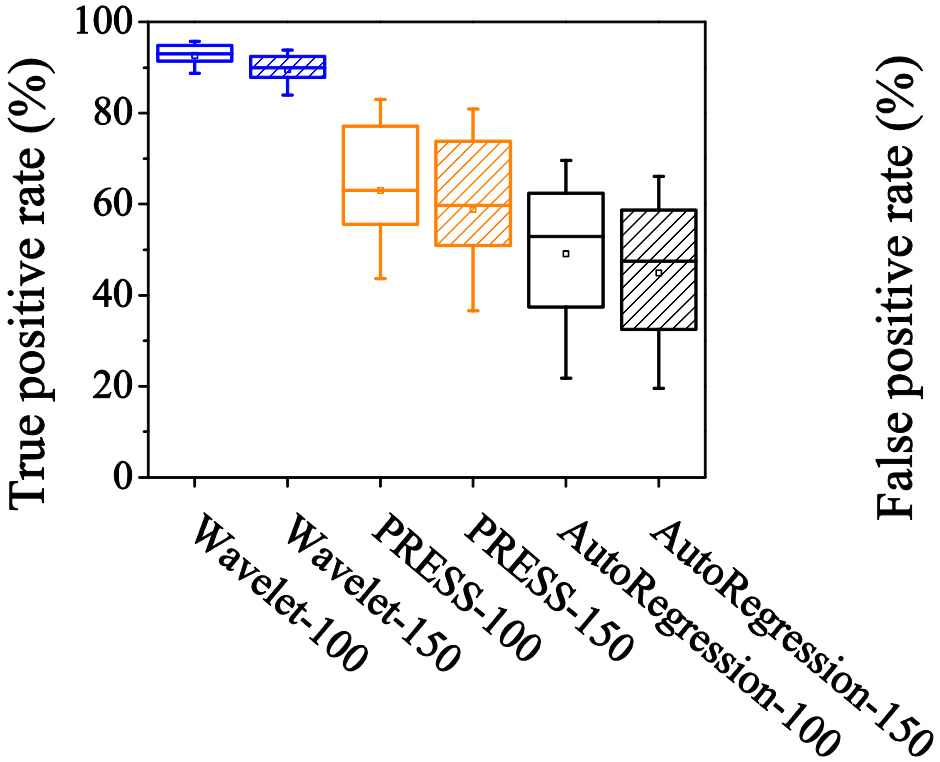
Wavelet-based prediction accuracy

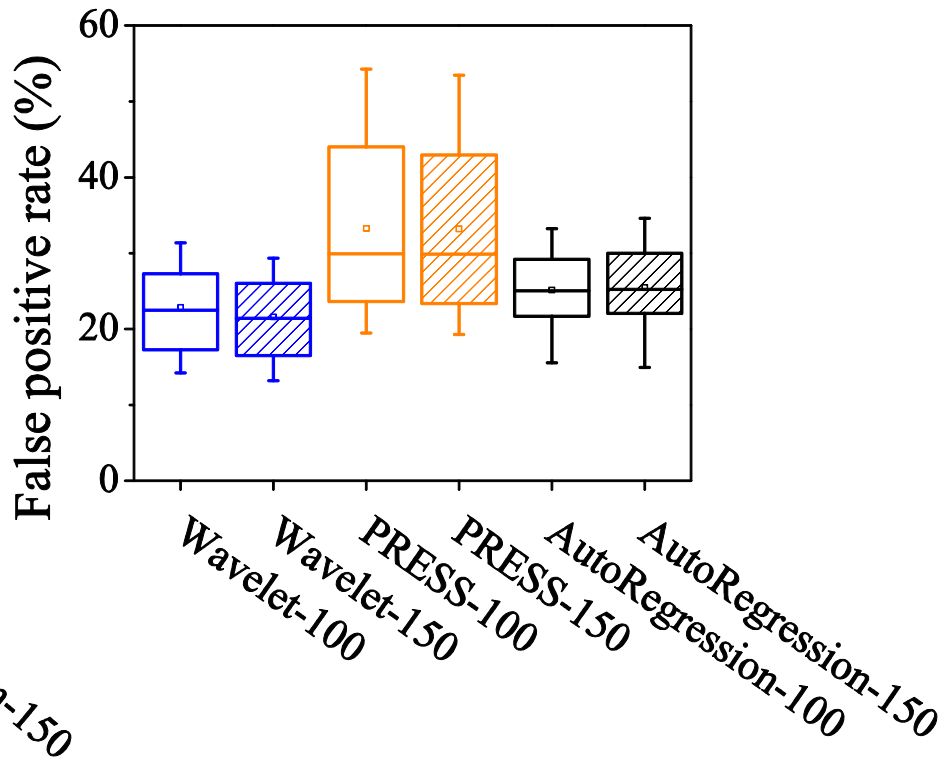
- RUBiS traces



Wavelet-based prediction accuracy

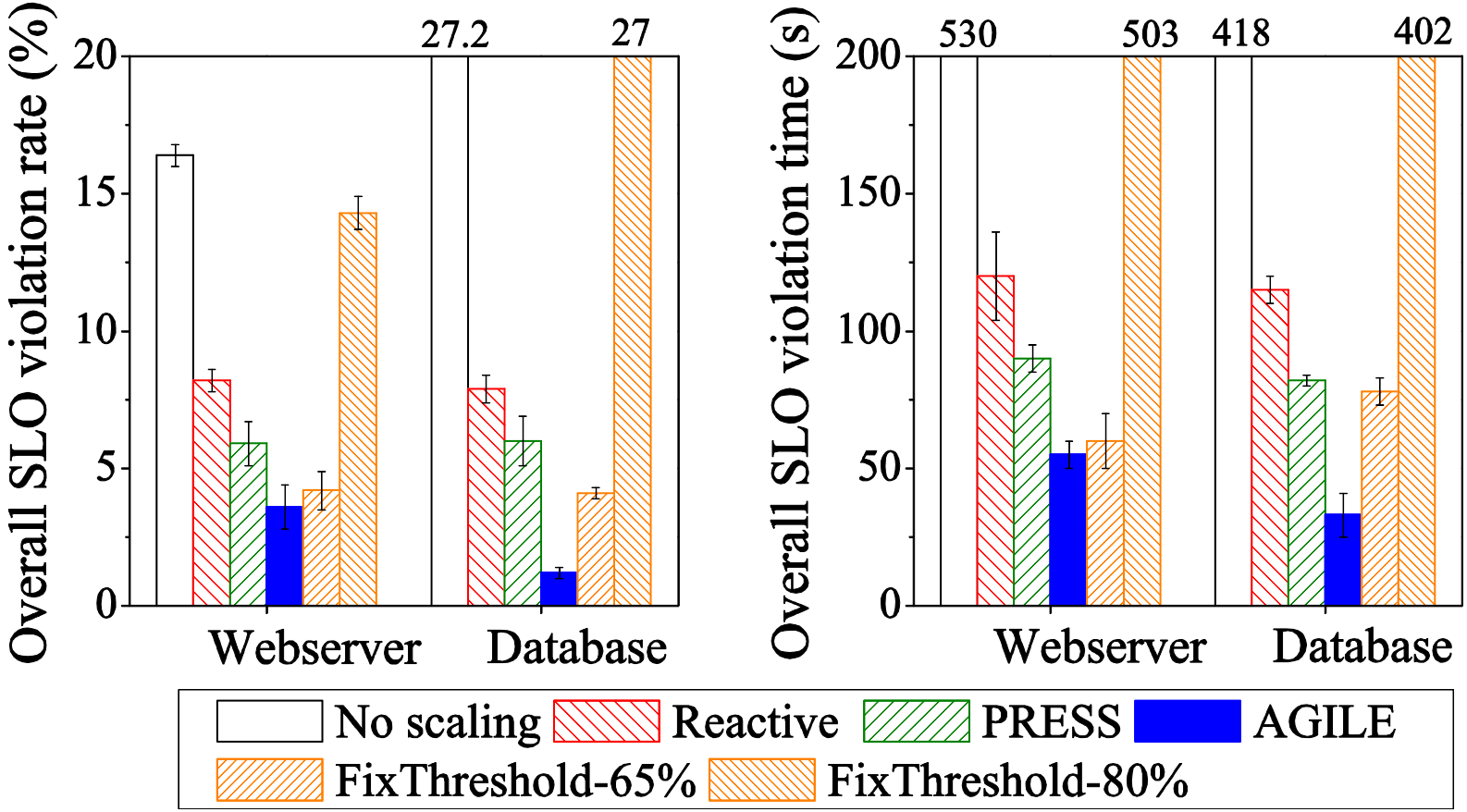
- Google CPU traces





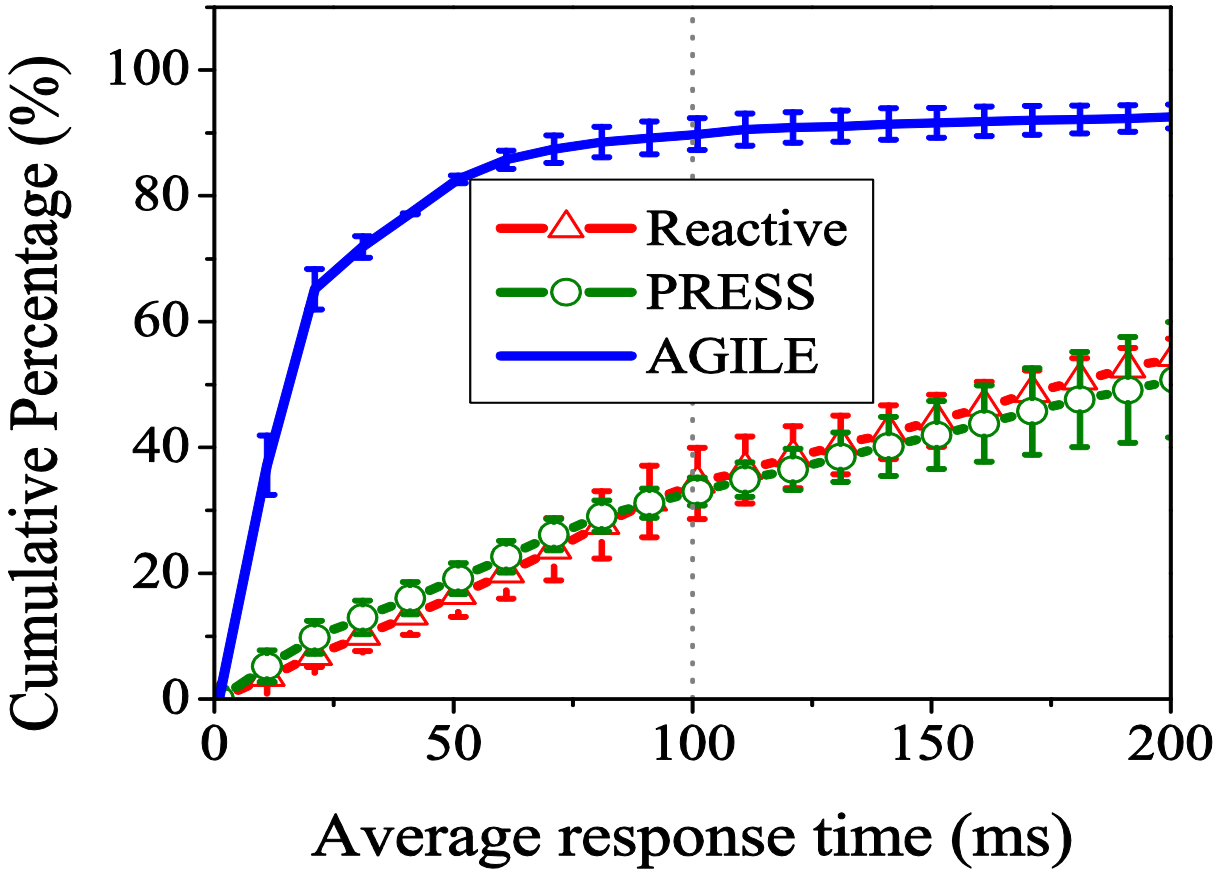
Overload handling

- Web server and database server scaling (≈ 2 hours, scale from 1 to 2 servers)

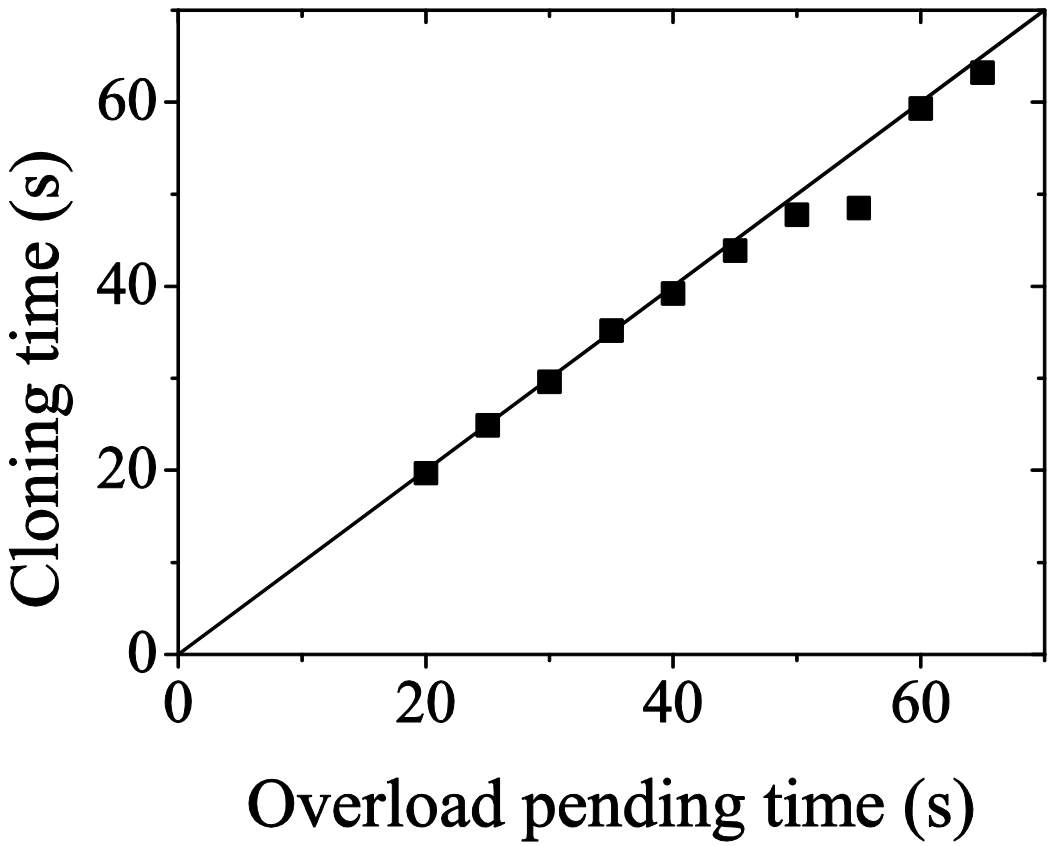


Overload handling

- Web server: during scaling



Dynamic copy-rate configuration



Accurately control the cloning time under different deadlines

Conclusion

- Prediction-driven elastic distributed resource scaling:
  - Accurate medium-term prediction based on wavelet transforms
  - Adaptive copy-rate to minimize interference
  - Application-agnostic performance model
- Immediate performance scale-up with little overhead

Thank you!

http://dance.csc.ncsu.edu

Acknowledgement

- This work was sponsored in part by NSF CNS0915567 grant, NSF CNS0915861 grant, U.S. Army Research Office (ARO) under grant W911NF-10-1-0273, and Google Research Awards