BORDERS

A Department of Homeland Security Center of Excellence

System Resilience: Implications to Border Management

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Resilience?

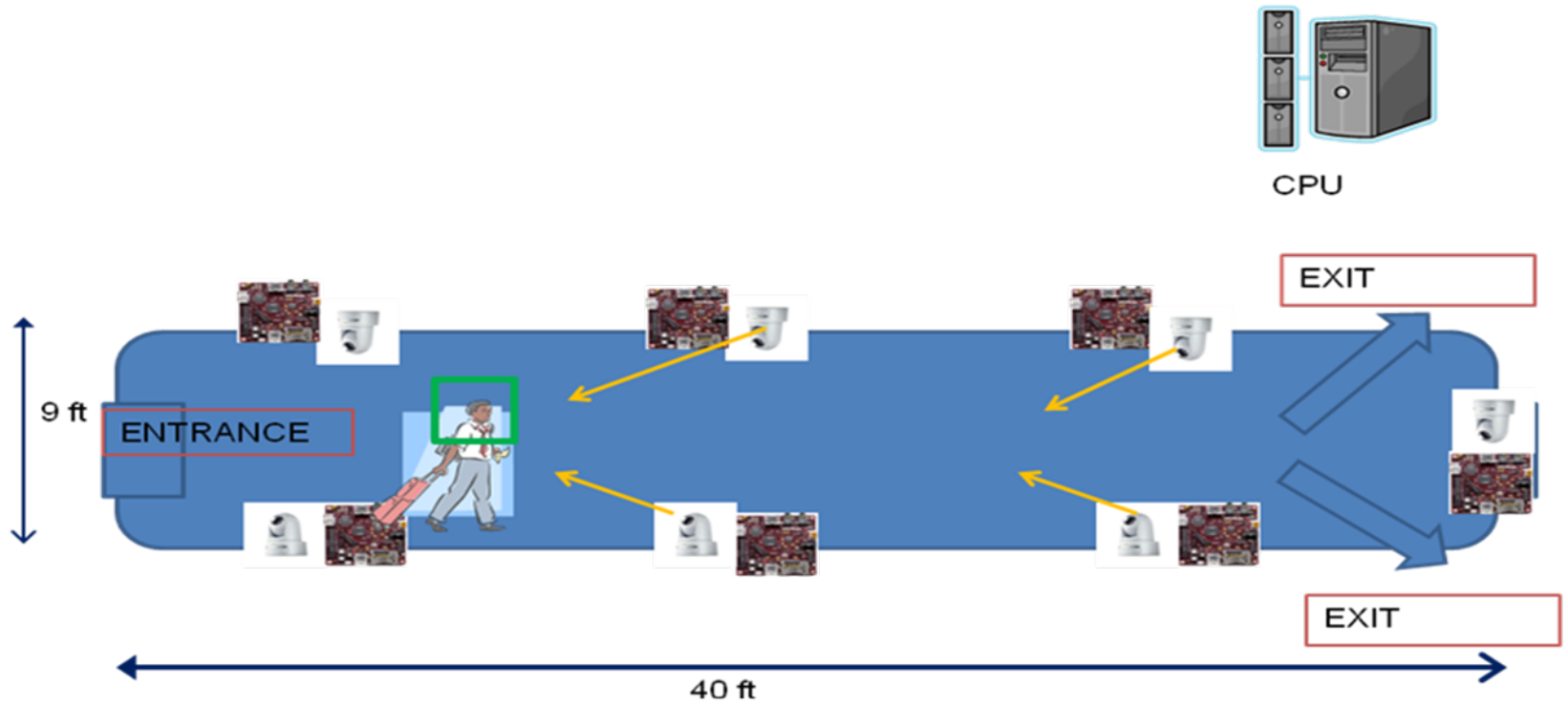
- **Computer systems fail.**
  - Correctness is an aspiration, reliable operation is a goal.
  - Fault tolerance for foreseeable failure causes / modes.
  - Not sufficient for critical infrastructures.
- **Expectation of service regardless of the source of the problem**
  - Unanticipated events
  - Changing system requirements
  - Changing environments and workload patterns.

Resilience Technologies

- **Evolvability**
  - Maintaining resilience during operations, recovery and fault handling, adaptation and reconfiguration.
- **Assessability**
  - The ability of a system to assess its correct functioning and quality of service delivered under both nominal and stressful conditions.
- **Usability**
  - Helping users understand the potential effects of their actions as well as preventing them from taking actions with unwanted and difficult to anticipate system-level effects.
- **Diversity**
  - the use of components that can perform similar functions in the system context but differ in some essential aspect that affects their vulnerability.

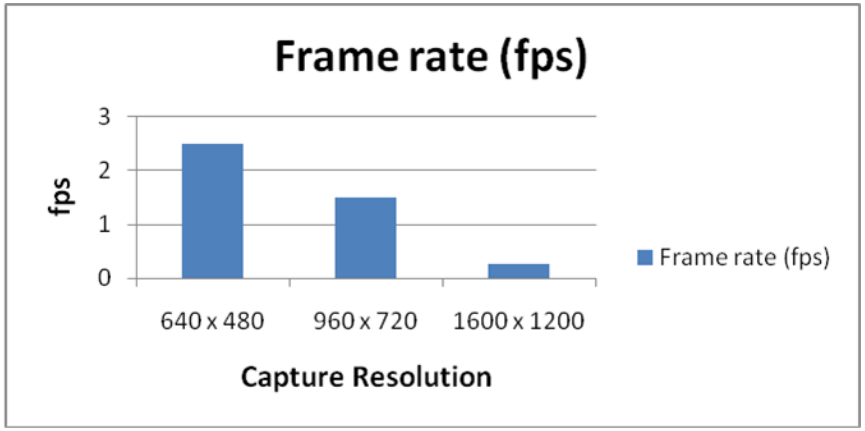
Diversity for Resilience

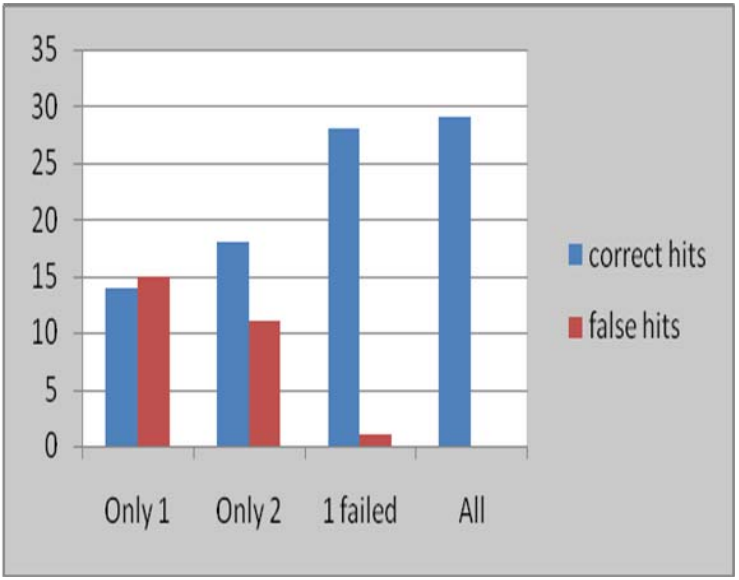
- **Decentralized airport passenger monitoring**
  - Sensor networks (vs. centralized PTZ cameras)
  - Early detection of watch-listed passengers (face recognition)

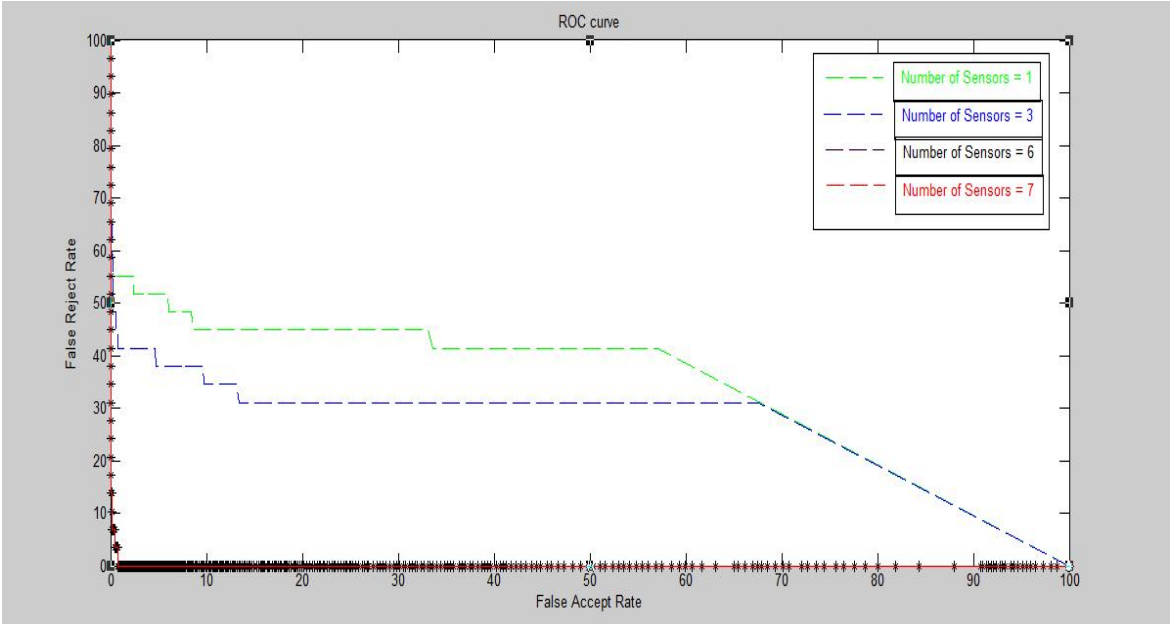


Diversity (2)

- **Technical trade-offs**
  - **Resolution vs. frame rate**
  - **On board face recognition saves bandwidth**
  - **How many cameras?**

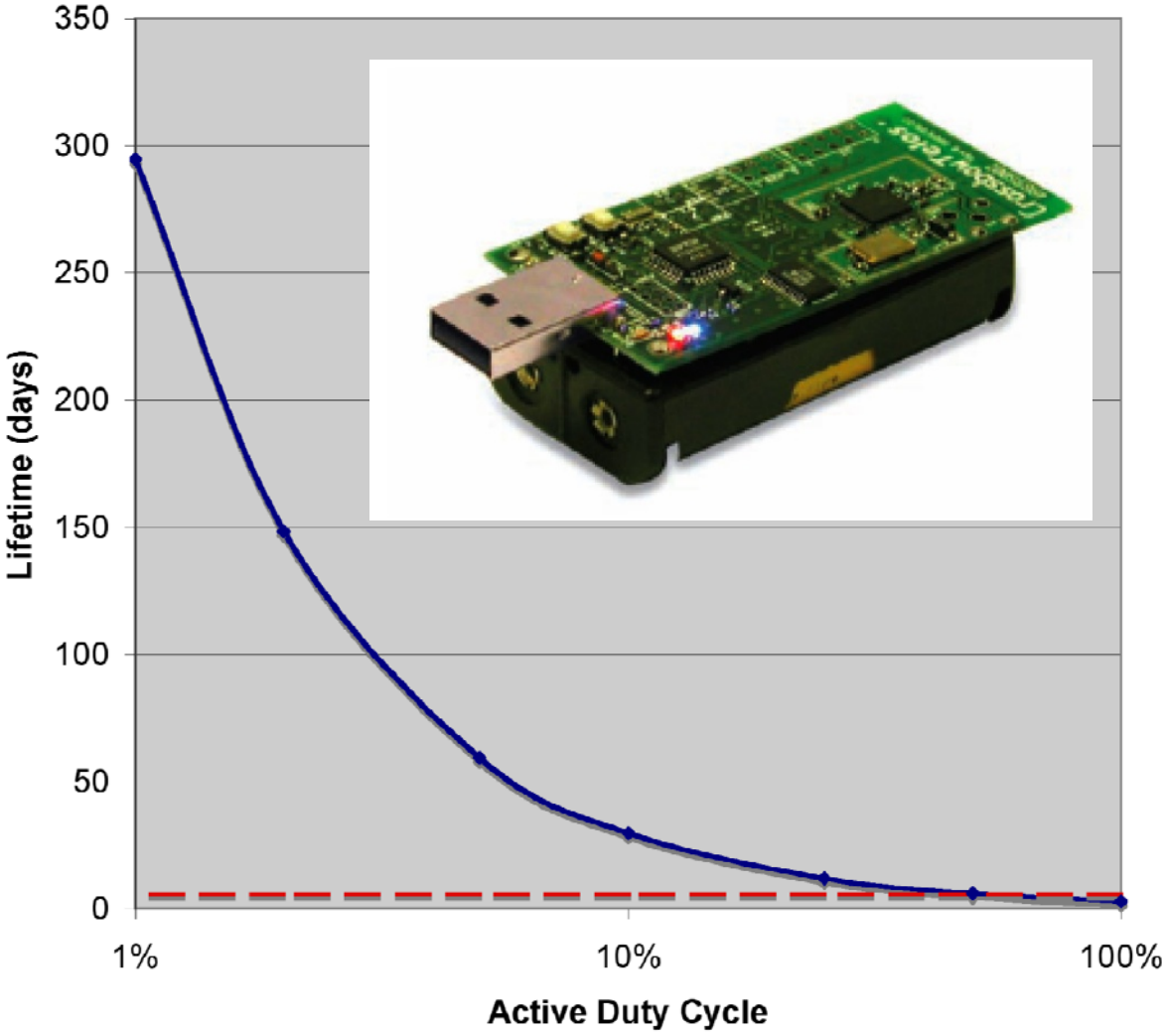






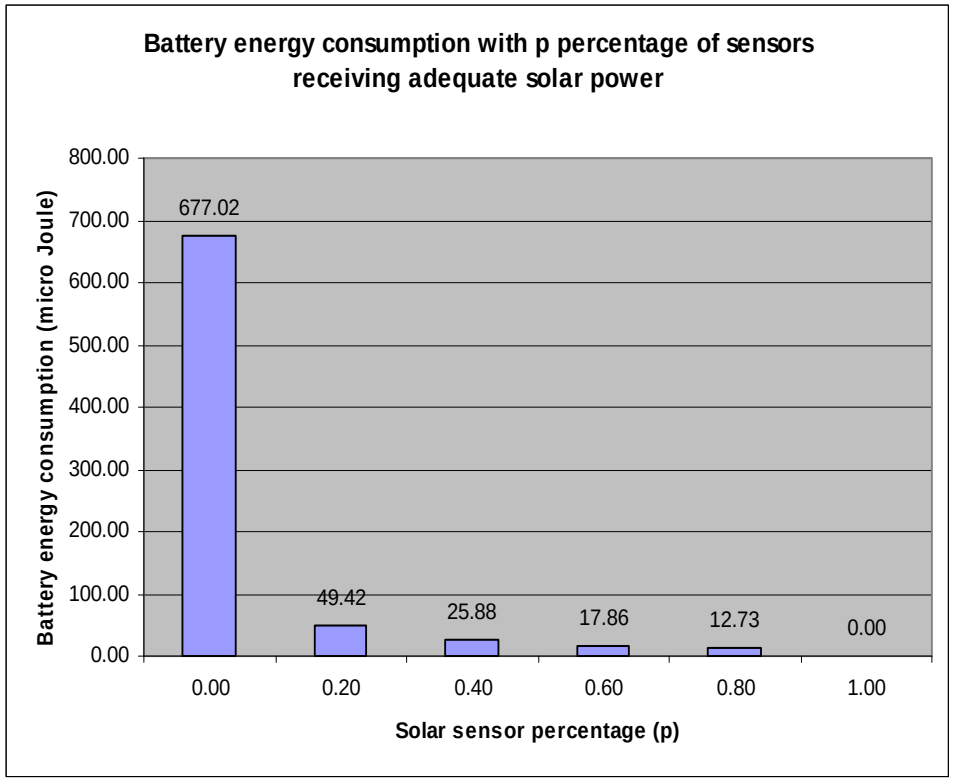
Evolvability

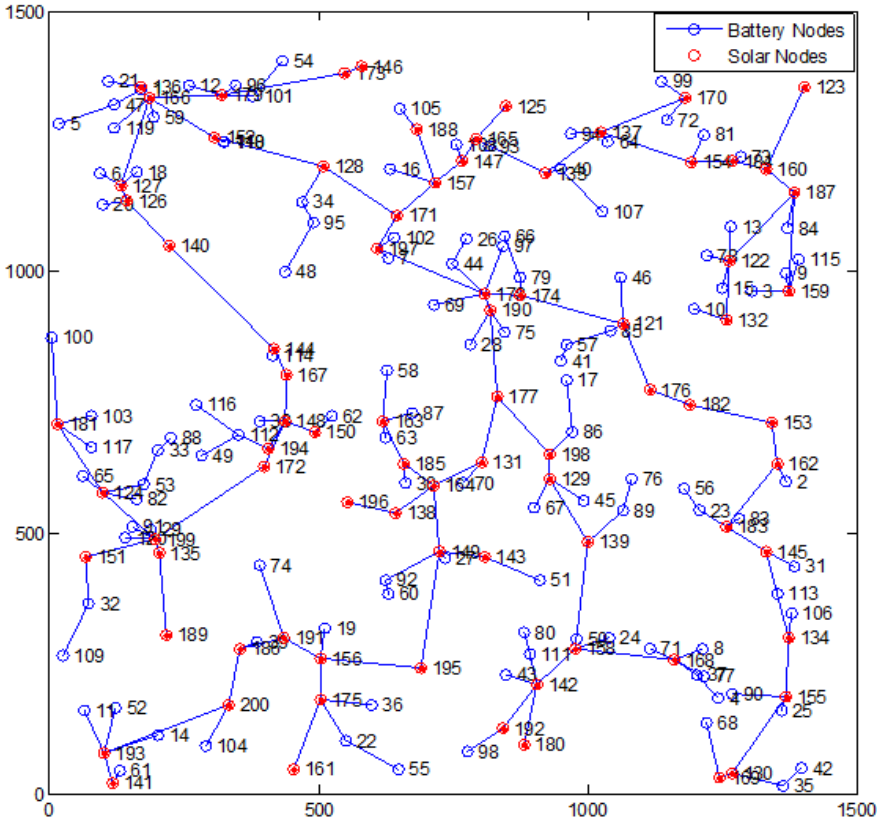
- **Idea:**
  - **Rest nodes to reduce maintenance!**
- **Topology-adaptive:** **Sleeping nodes leave network connected**
- **Energy-adaptive:** **Low-energy nodes sleep earlier, longer**
- **Non-synchronous:** **Sleep periods are fully asynchronous**



Evolvability (2)

- **Further enhancement: Solar powered sensors**
  - **As network becomes larger, about 20% of solar powered sensors can significantly reduce battery power consumption (20 nodes, 47%; 100 nodes, 74%, 200 nodes 92.7%).**
  - **Backbone traffic handled by solar powered nodes.**





Self-assessment and adaptation

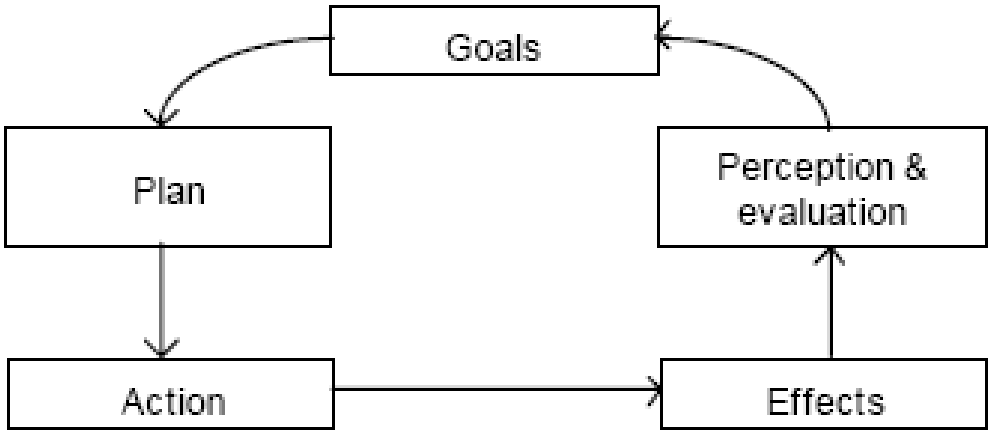
- **System can adapt its performance (passenger classification) when its environment changes.**
  - **Threat levels, varying passenger traffic…**

Table 4. Combined performance and risk modeling assuming the use of fingerprint biometrics

$p(+)$	μ	PC	FNMR	FMR	$Norm(E[Cost])$	Total waiting time (min)
10-3	10-2	0.090991811	0.0001834	0.0031	0.000448787	25.91287
	10-4	0.909173561	0.002026	0.0006	0.000729519	36.65966
	10-6	0.999001997	0.002026	0.0006	0.000601423	36.65966
	10-8	0.99999001	0.002026	0.0006	0.000600014	36.65966
10-5	10-2	0.000999011	0.00005376	0.0059	5.96005E-05	19.40537
	10-4	0.090909917	0.0001834	0.0031	0.000448548	20.16107
	10-6	0.909091736	0.002026	0.0006	0.000729635	30.90244
	10-8	0.999001009	0.002026	0.0006	0.000601425	30.90244
10-7	10-2	9.9999E-06	0.00005376	0.0059	5.38185E-05	19.34802
	10-4	0.000999001	0.00007478	0.0052	7.99001E-05	19.47052
	10-6	0.090909099	0.0001834	0.0031	0.000448545	20.10358
	10-8	0.909090917	0.002026	0.0006	0.000729636	30.84487

Usability

- **Understand the effects of actions before taking them.**
  - **Socio-technical systems**
  - **Evaluate system / effects as a whole, not its parts.**
    - **Reasonable approximation of effects is acceptable.**
    - **Ex: “Detection rate will be between 60 and 75%”**



Summary

- **Resilience is an essential requirement for socio-technical systems deployed at borders.**
- **Resilience technologies**
  - **Some mature:**
    - **Diversity in system design, fault tolerance.**
  - **Some emerging, bleeding edge technologies:**
    - **Evolvability, adaptation, self-assessment.**
  - **Some still beyond the technological bleeding edge:**
    - **User decision support, real-time global system modeling capabilities.**