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SPARK: Smart Building Fire Prediction And Risk Analysis






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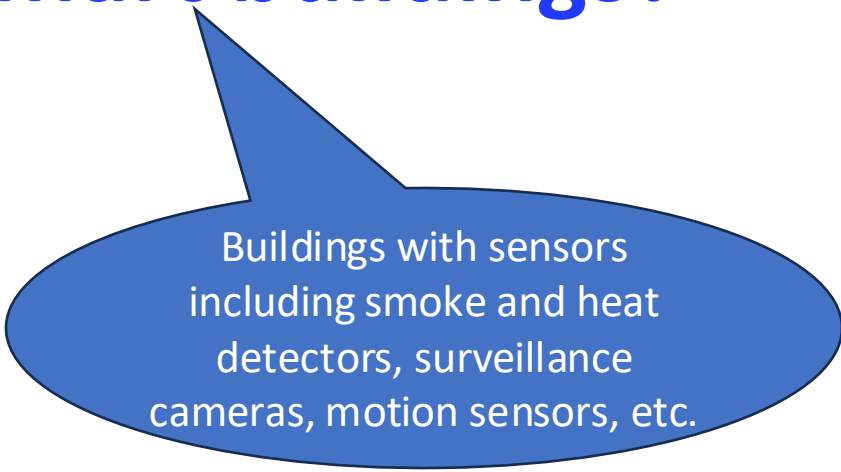
Outline

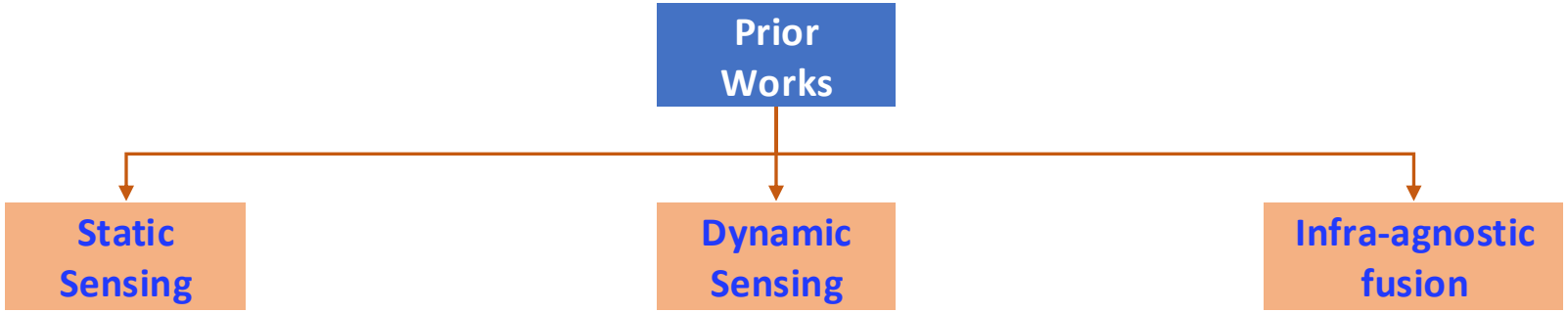
- Objective
- Existing Works
- Our Contribution: SPARK
- Experiment Results
- Conclusion

Objective

Can we develop a system/technique for fire prediction in smart buildings?



Existing Work for Fire Prediction in Smart Buildings



- Consistent sensing
- Low latency alarms

- Blind spots
- Outages reduce coverage
- Ignores building connectivity

- Can reach unsafe zones
- On demand

- Intermittent/latency-prone
- Noisy and less accurate

- Employes different sensor types
- Robust to missing sensors

- Cannot anticipate indirect spread
- Lacks multi-hop diffusion

Contribution

SPARK

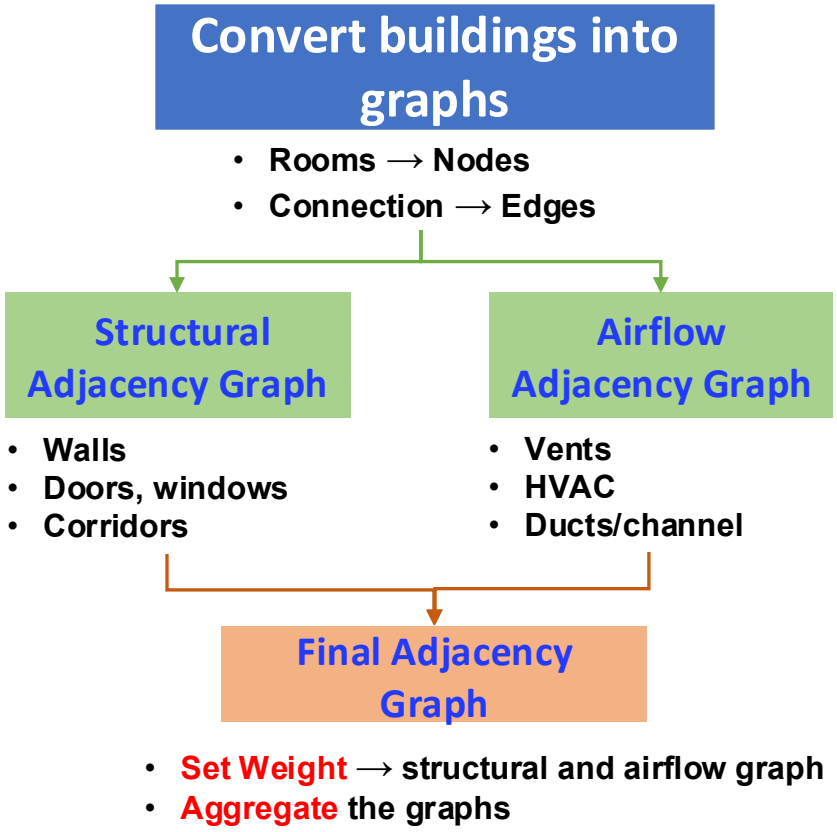
Integrates heterogeneous sources (static, dynamic, and human) and room attributes to accurately predict fire spread in smart buildings

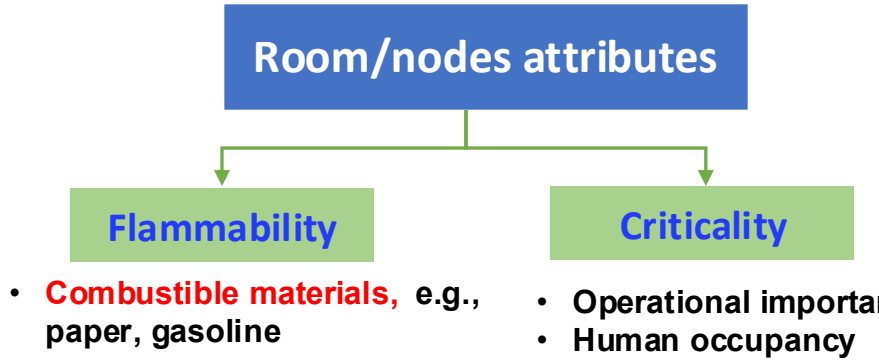
SPARK Accuracy ≈96% (for 10 floor buildings with 20 rooms on each floor)

SPARK: Algorithm Overview

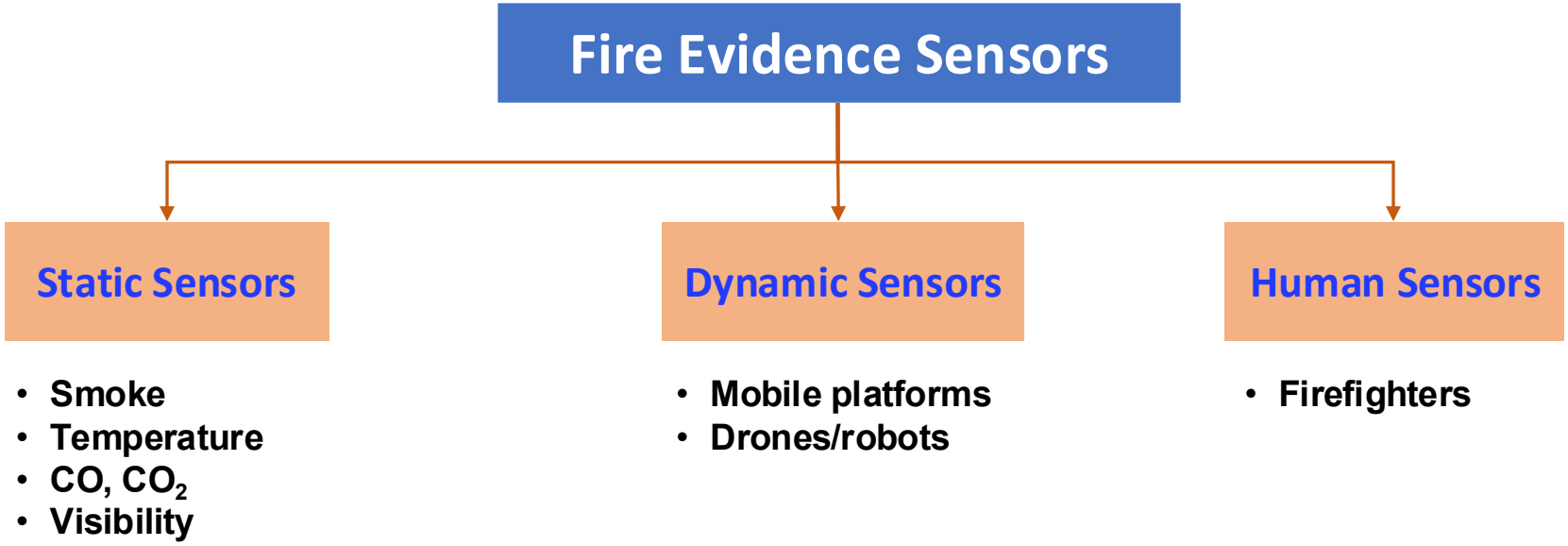
- Phase 1: **Modeling** a building
- Phase 2: Sensor **data collection**
- Phase 3: Sensor data **normalization** and **fusion**
- Phase 4: Fire **propagation** (room attributes and neighbors)
- Phase 5: Risk-Zone **Clustering**

SPARK: Phase 1 - Modeling a Building

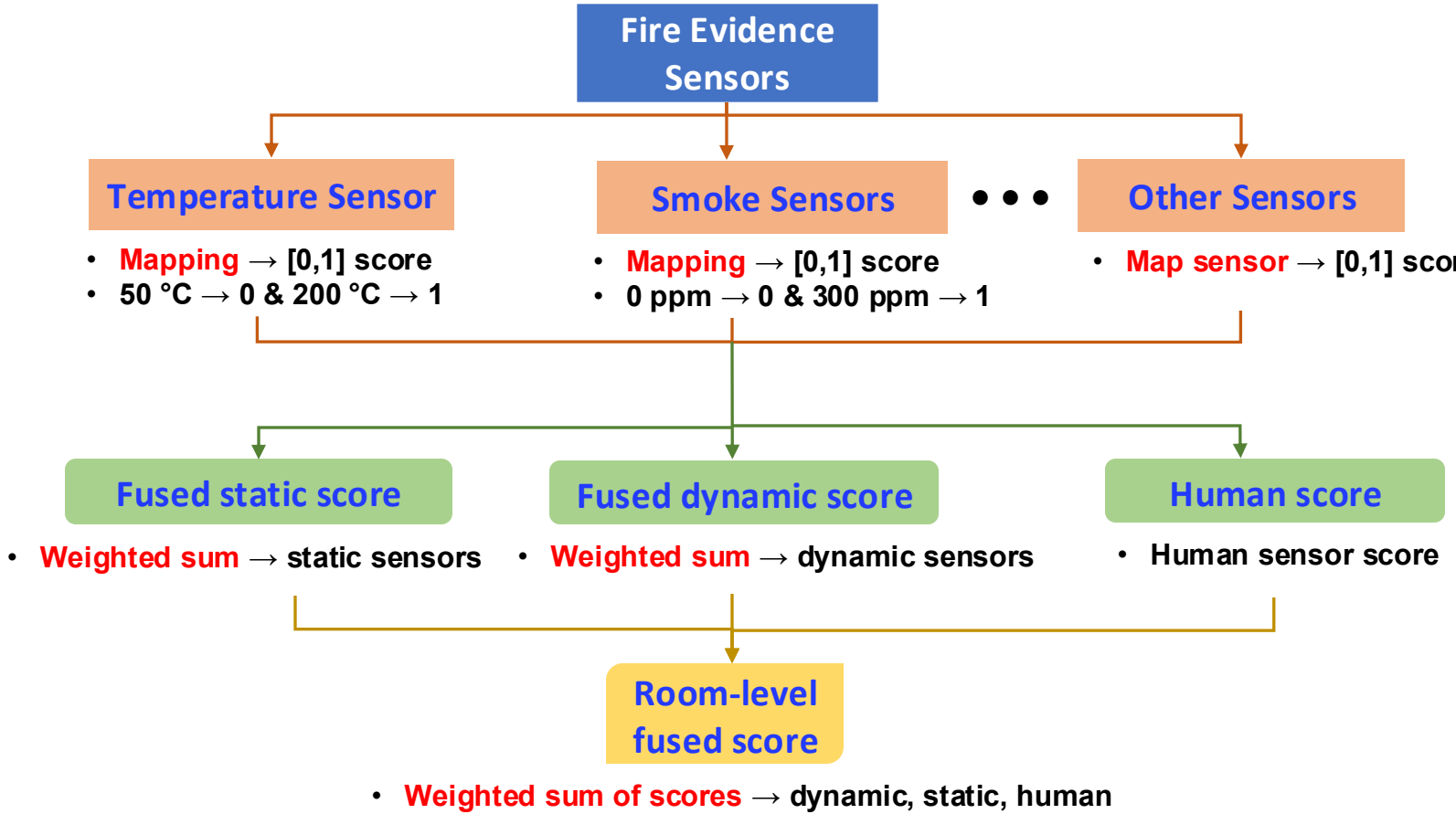




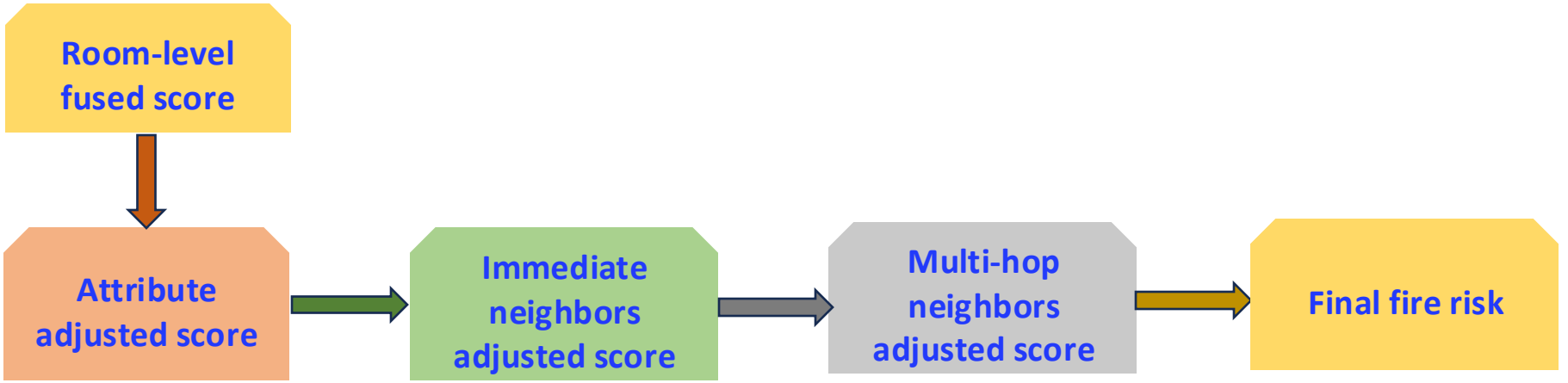
SPARK : Phase 2 – Sensor Data Collection



SPARK : Phase 3 – Data Normalization and Fusion



SPARK : Phase 4 – Fire Propagation



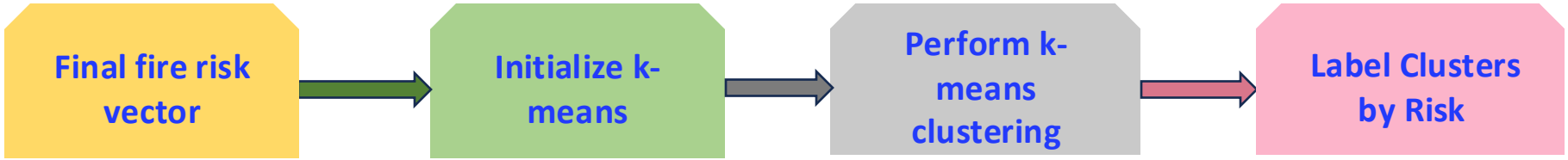
- Room Attributes → flammability, criticality
- Scale score → combine factors and multiply

- Find neighbors → use adjacency graph
- Aggregate neighbor scores

- Row-normalized → adjacency graph
- Attenuation factor
- Graph diffusion → multi-hop propagation

- Final multi-hop neighbor & attribute adjusted risk

SPARK : Phase 5 – Risk-Zone Clustering



- Fire risk values for all rooms
- Clustering input

- Set k = 3
- Safe
- Vulnerable
- Critical

- Assign rooms → nearest center
- Recompute centers
- Repeat until convergence

- Center value Low to high → Safe, Vulnerable & Critical
- Room zone → cluster assignment

Experiment Results

- **Simulator**: NIST Fire Dynamics Simulator (FDS)
- **Layouts**: 3-floor and 10-floor buildings
- **Rooms**: 20 rooms per floor (60 rooms & 200 rooms)

Experiment Results

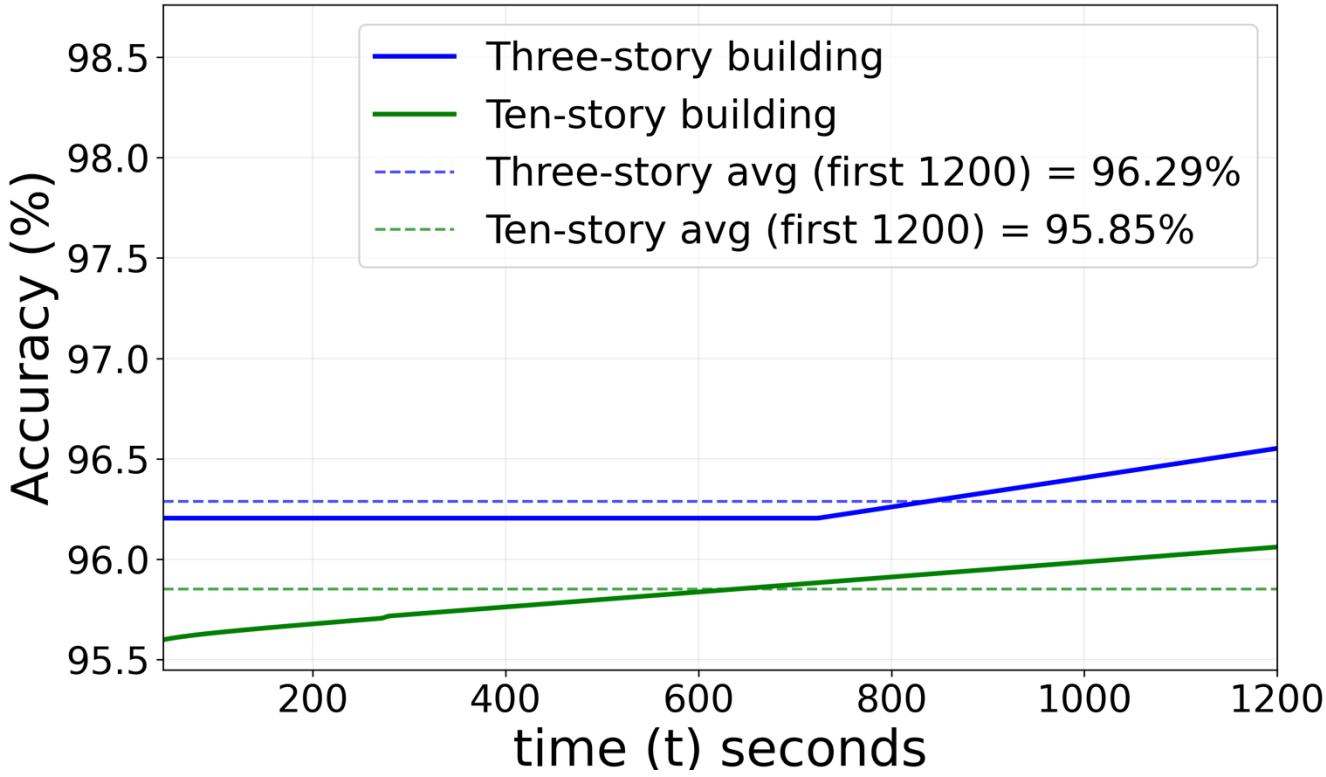


Figure: Prediction accuracy (%) of SPARK over time. Accuracy at epoch *t* is defined as the percentage of rooms correctly predicted for fire spread.

Experiment Results

Building	Static-Only	Dynamic-Only	Dynamic + Static
Three-floor	97.12	94.77	98.09
Ten-floor	95.31	91.67	97.06

Table: prediction accuracy (%) of SPARK under different sensor settings for three-story and ten-story buildings.

Conclusion

- **SPARK : A fire-prediction system for smart buildings**

- Incorporates:
  - Static, dynamic/mobile and human sensors
  - Room attributes (e.g., flammability)

- **≈96%** accuracy at identifying vulnerable rooms

Thank You

Slides are available online: https://web.njit.edu/~ss797/

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