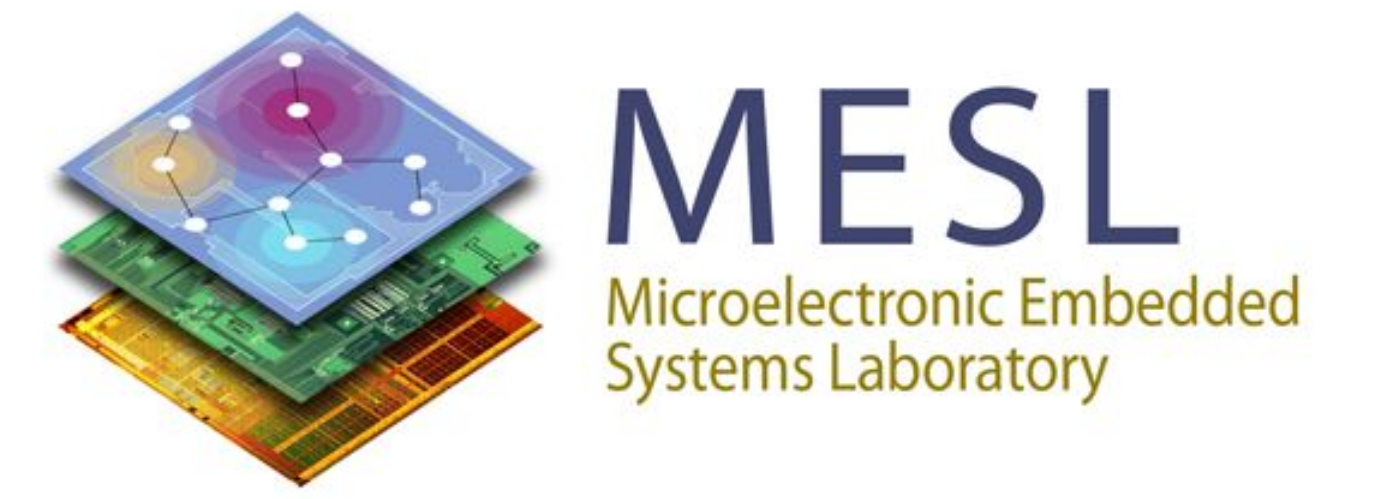


# Metadata Organization for Energy Efficient Operation of Smart Buildings

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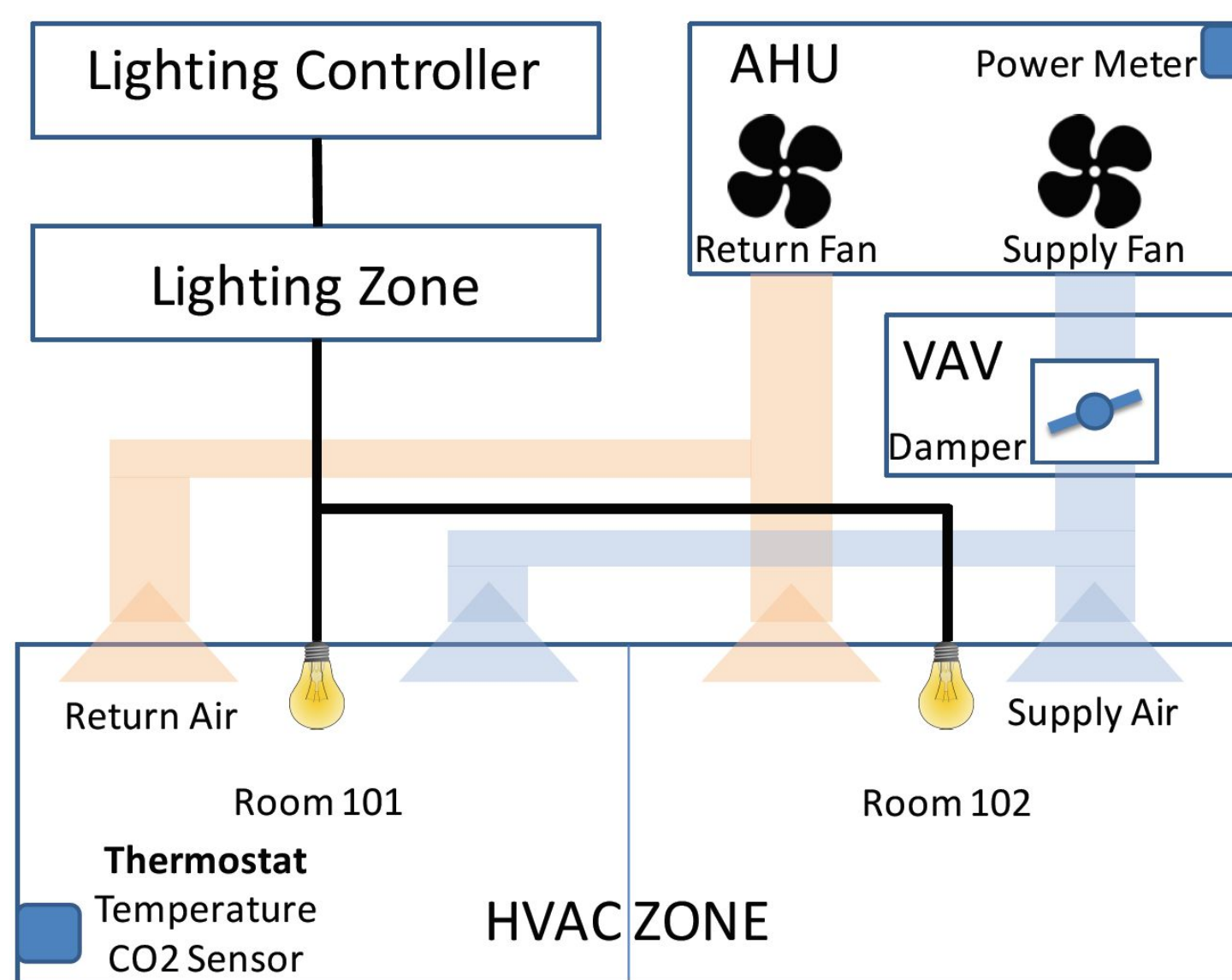
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<https://brickschema.org>  
Brick Open-sourced Building Data Schema

## Why Smart Buildings?

- Buildings account 32% of the energy usage worldwide.
- They are very often
  - Operated for vacant spaces (possibly 15 % easy saving)
  - Overcooled,
  - Using broken devices (possibly 40 % easy saving)
- Software engineering can help!
  - Automatic fault analysis
  - Model predictive energy efficient control
- However, buildings are complex!



- Numerous subsystems
  - Lighting system, HVAC, elevators, security
- Numerous sensors
  - 5,000 - 10,000 in a medium-sized building.
- Complex structure
  - Hundreds of rooms, thousands of people reside in and interact with a building.

How to get the right information from this complex system?

## Unstructured Metadata in Real World

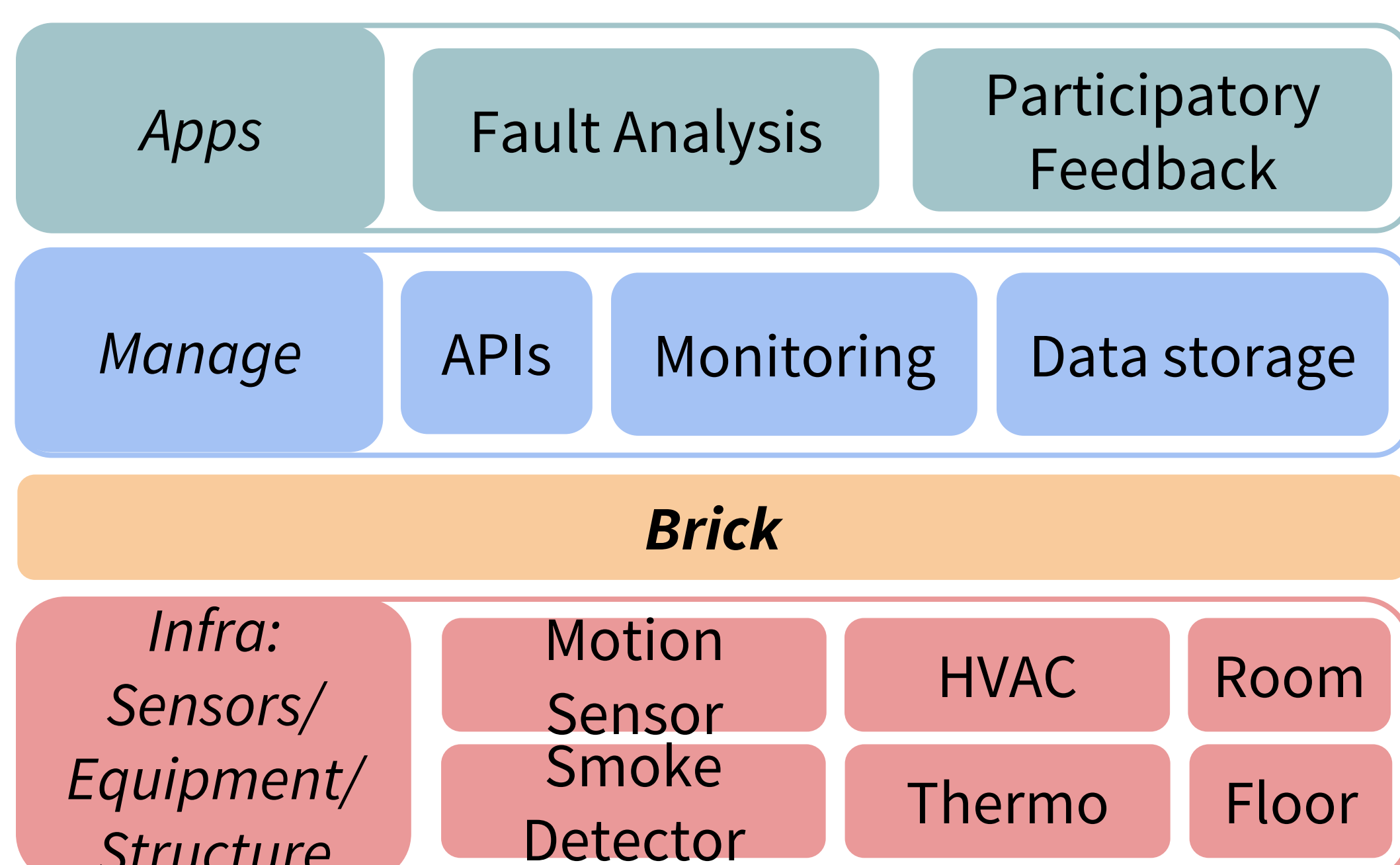
- Only human-readable
- Non-standardized across buildings and even in a building
- System manager needs a huge effort to curate metadata.

Vendor Given Information	Human Interpretation		
Raw Metadata	Point Type	Location	Equip
ENG.CRAC-1.TEMPSETF	Temperature Setpoint	N/A	CRAC-1
SC-CRAC-1-MIG-008.Tmp	Temperature Sensor	N/A	CRAC-1
SC.3FLW-HALL.ZN-T	Zone Temperature Sensor	3rd Floor, West-Hall	N/A

Needs a common semantic layer for application interoperability & portability

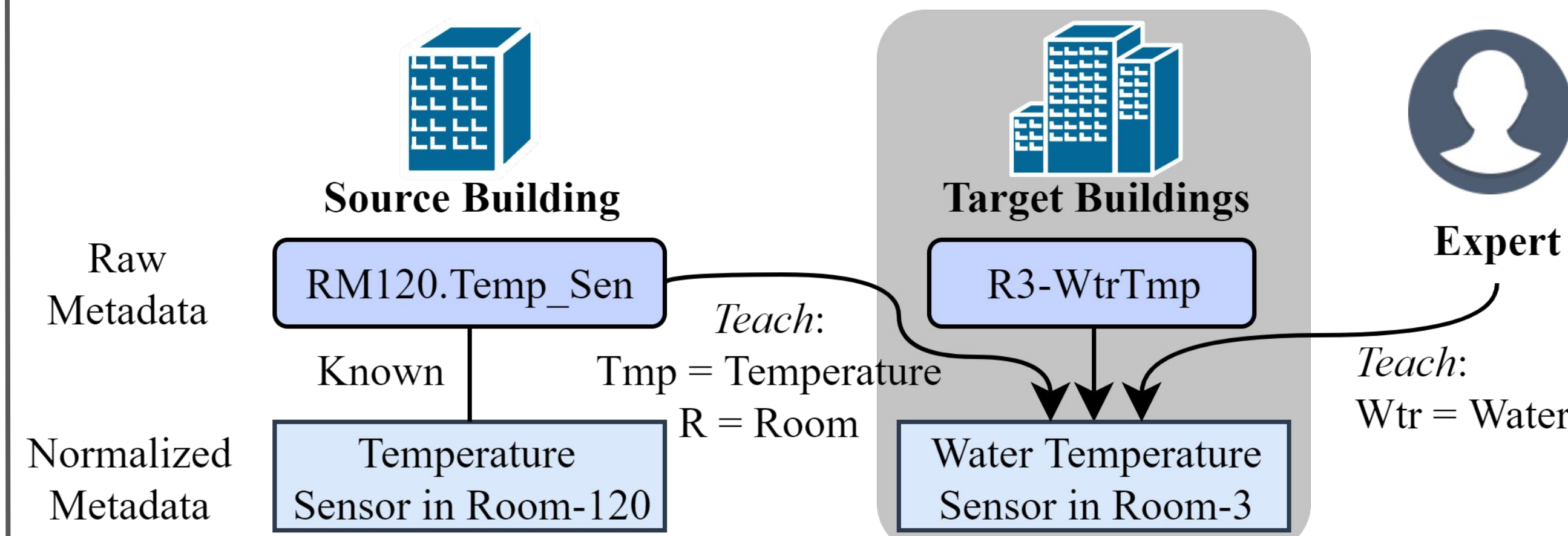
## Brick: Building Metadata Schema

- Complete, Expressive, Usable schema for portable applications.
- Open source and community development
  - Initiated by multiple institute as UCSD, CMU, UCB, UVA, SDU, IBM
- Industrial adoption: Google, Johnson Controls, ASHRAE, etc.

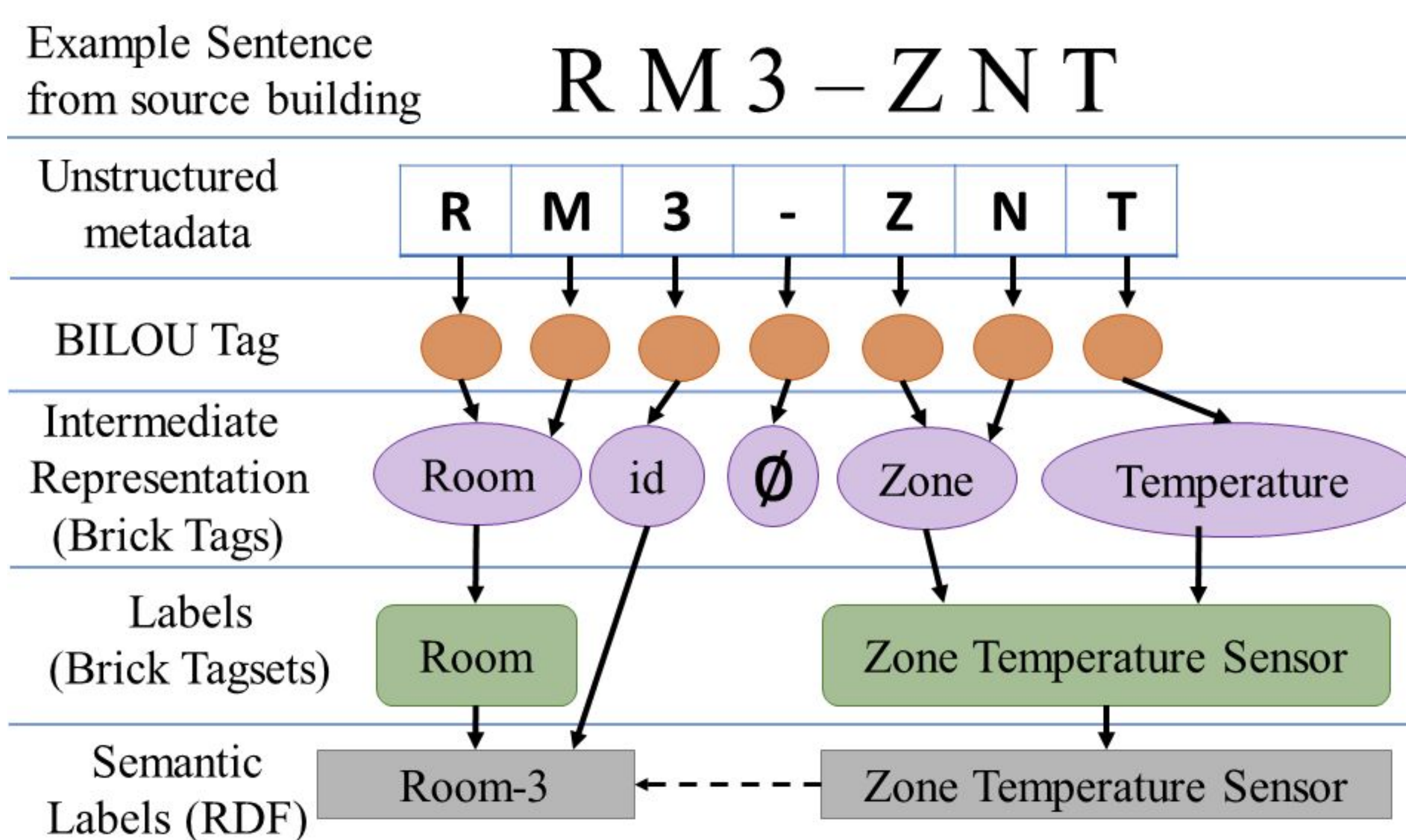


## Scrabble: Semi-Automated metadata Normalization

- The major bottleneck to deploy Brick is **the large human effort to map "metadata" into a usable format.**

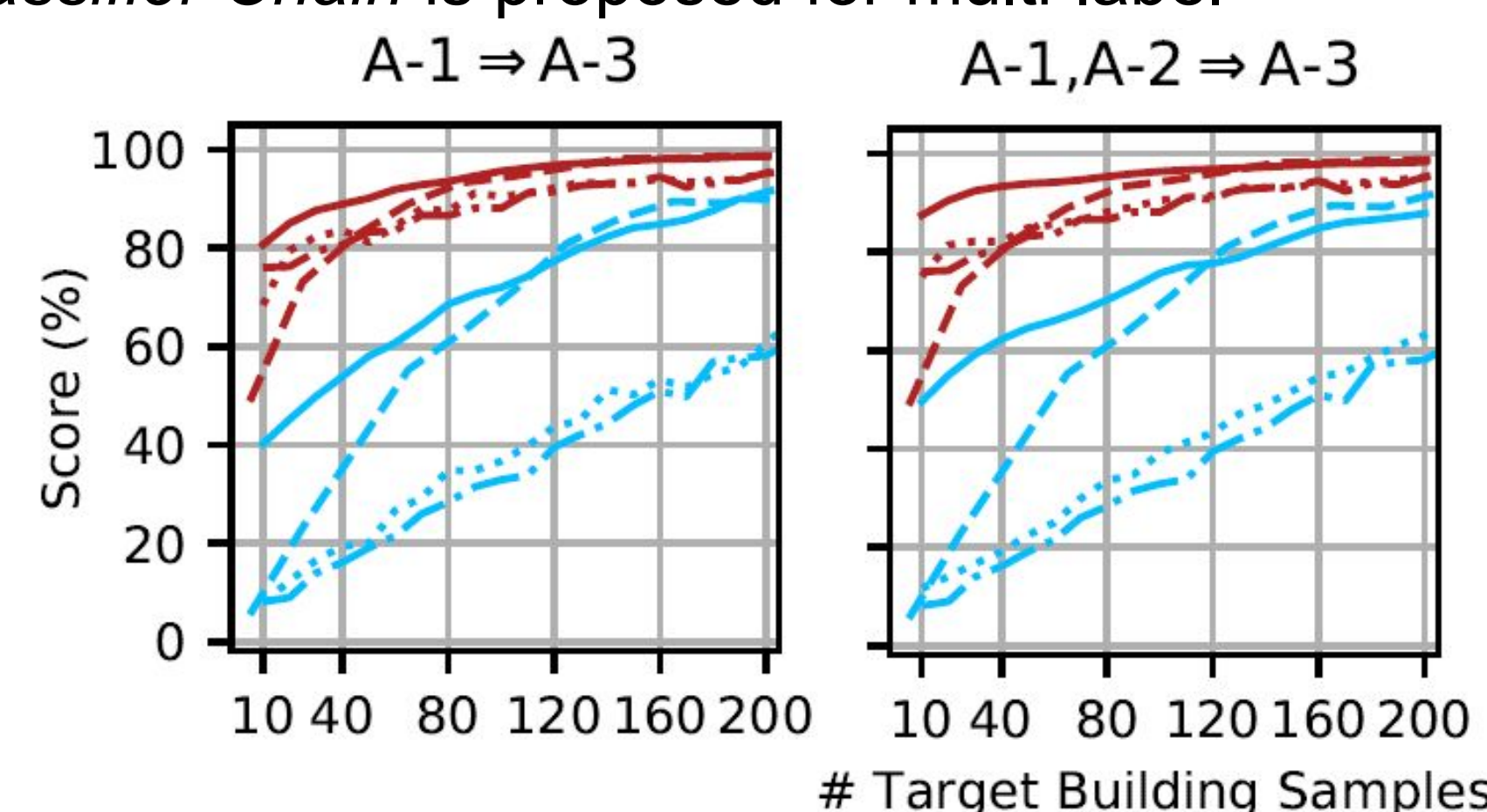


- Let's use already known mappings, and if unknown, ask experts.



- Basic Idea:**
  - Character => Tags would be more reusable than TagSets. E.g., If ZN=Zone is known, ZN in ZNT, ZN-T and ZN-1 can be known.
  - Tags => TagSets are given or easy to learn. E.g., obviously, {Zone, Temperature, Sensor} => Zone\_Temperature\_Sensor
  - Two stages learning will help reusing existing knowledge.
- Character-level entity recognition using CRF.**
  - R -> Beginning of RM for "Room".
  - M -> Inside RM for "Room" (BIO)
  - Provide character-level error resiliency.
  - No predefined delineation rule is required.

- Mapping Tags to TagSets by a multilabel classifier.**
  - {Room, Zone, Temperature} -> {Room, Zone\_Temperature\_Sensor}
  - This layer is resilient to variations as mappings are somewhat known by Brick's structure.
  - Structured Classifier Chain is proposed for multi-label classification.



## Conclusion

- Structured Metadata will enable a large deployment of energy efficient applications that can save 15 - 40 %.
  - It is more important than improving algorithms.
- Brick shows the most usable and comprehensive metadata schema for smart building applications.
  - Both academic and industrial adoptions are happening.
- Scrabble significantly helps reducing the efforts to instantiate structured metadata.
  - By far the best versatile algorithm.

## Future Goals

- Constructing an app store ecosystem for smart buildings/cities.
  - Building/Brick emulator for prototyping application development.
- Prepare for the industrial adoption of Brick.
  - Preparing for a consortium.
- Exploiting various information sources to create structured metadata.
- Scalable and secure data sharing
- Development of real applications using Brick.
  - Reinforcement Learning on HVAC operations.

## Call for Participation

- If you are a building manager, contact us to discuss **Bricify your building** for easier app deployment.
- If you are a domain experts, contact us to **expand Brick to your systems** (like lighting systems.)
- If you are a student, be aware of the building energy usage is very large and try to adopt relevant technologies or new devices.

## References

- Brick: <https://brickschema.org>
  - Brick: Metadata schema for portable smart building applications, Applied Energy 2018
- Scrabble: <https://github.com/jbkoh/scrabble>
  - Scrabble: converting unstructured metadata into brick for many buildings, BuildSys 2017
- BuildingDepot: <https://buildingdepot.org>

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