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Generating traffic-based building occupancy schedules in Chattanooga, Tennessee from a grid of traffic sensors

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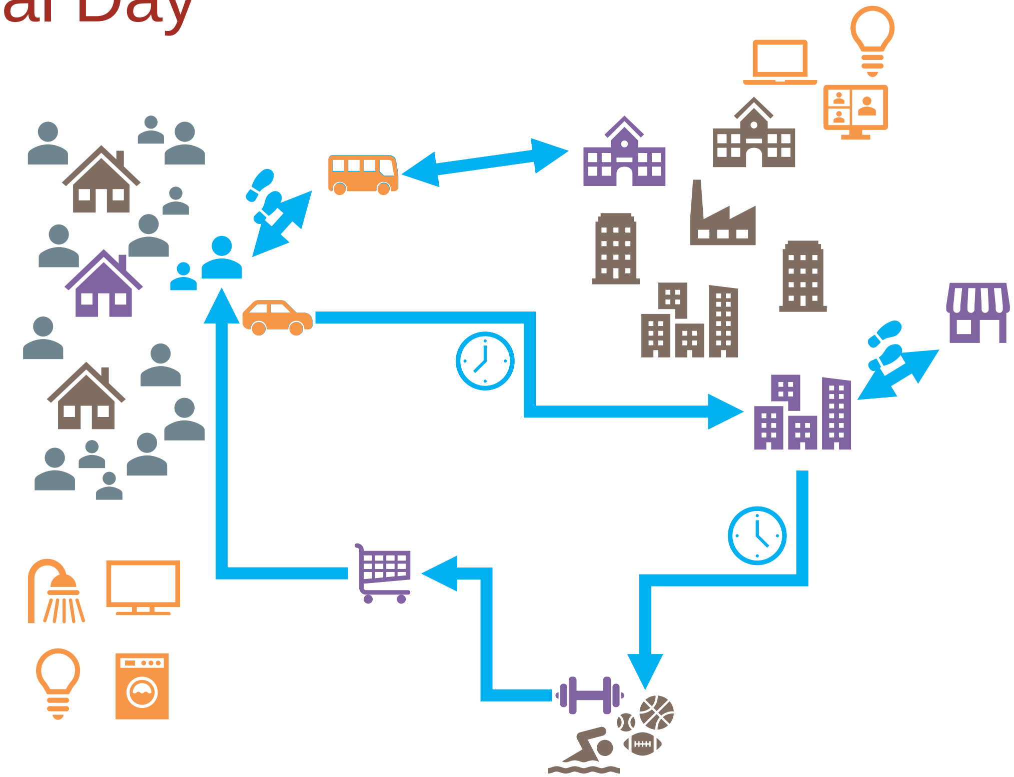
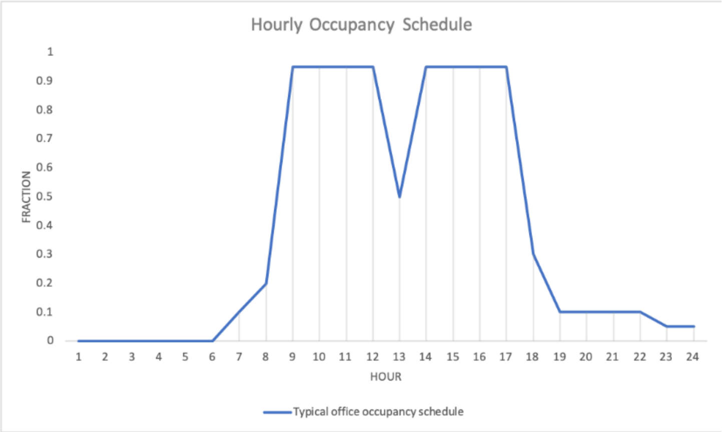
A Typical Day



Stock Schedules for Building Occupancy

Static, identical occupancy schedules for each building do not capture variations between buildings, cities, etc.



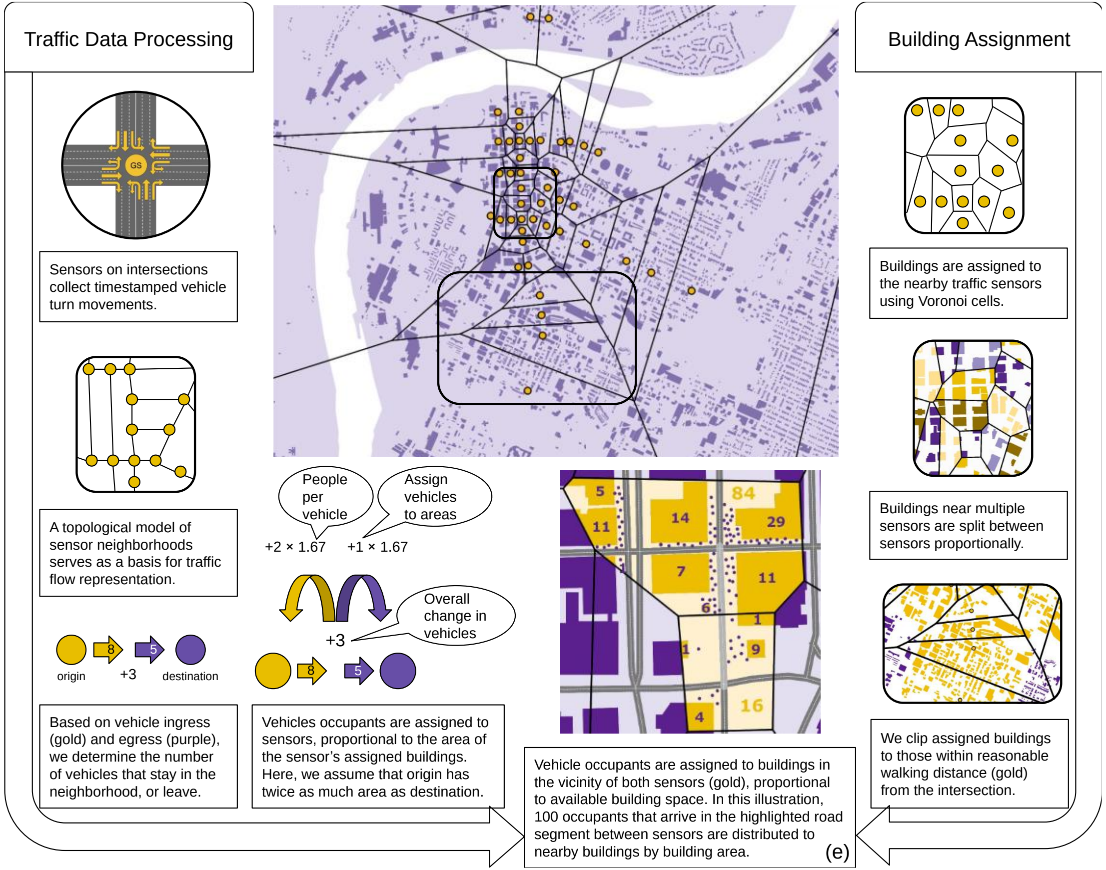
Source:
US Department of Energy. Commercial prototype building models | building energy codes program, 2013.
https://www.energycodes.gov/development/commercial/prototype-models

Traffic Data for Building Occupancy

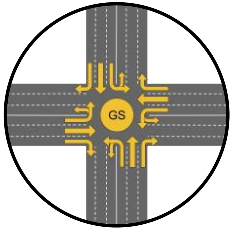
- Traffic data provides insights about the population's daily movements
  1. Determine origin and destination of each vehicle's trip
  2. Assign to nearby buildings
  3. Create a customized occupancy schedule from hourly variations

Overview

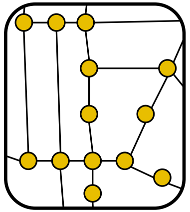
- Split workflow:
  - Traffic
  - Buildings



Creating Sensor Topology



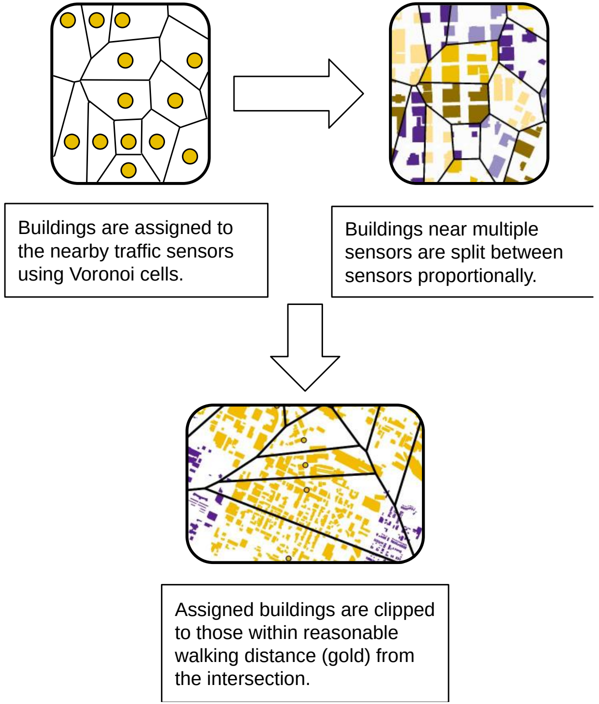
Sensors on intersections collect timestamped vehicle turn movements.



A topological model of sensor neighborhoods serves as a basis for traffic flow representation.

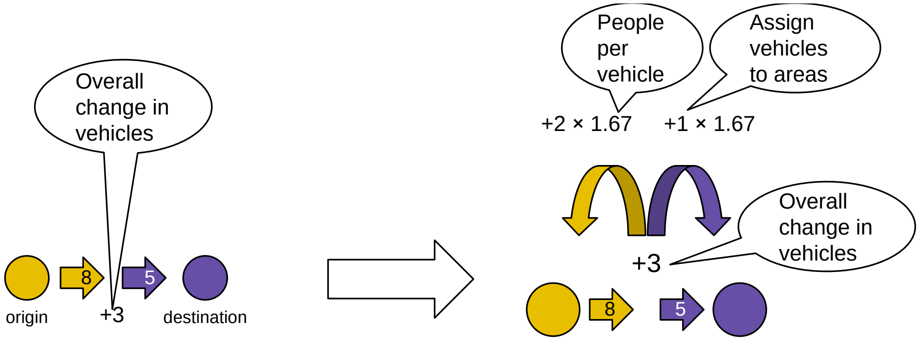
- Over 40 sensors in downtown Chattanooga
- Sensors track vehicle movements
  - Data for every single vehicle (speed, length approach direction, turn direction)
  - Historic and real-time available
- To build traffic flow model:
  - Determine neighborhood
  - Create topological network

Assigning Buildings to Sensors



- Each sensor has a neighborhood defined by a Voronoi polygon
- Buildings that fall inside multiple polygons are split proportionally between sensors based on area
- Buildings outside walking distance are clipped

Understanding Traffic Flow

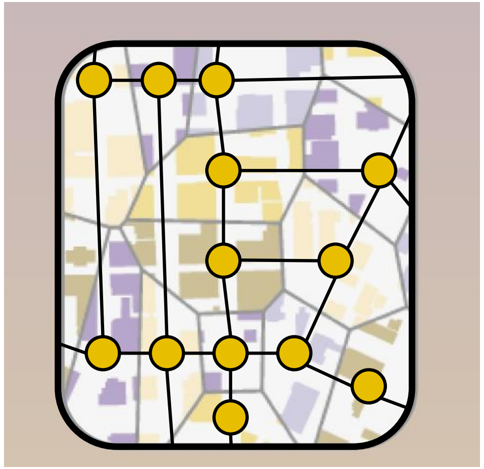


Based on vehicle ingress (gold) and egress (purple), we determine the number of vehicles that stay in the neighborhood, or leave.

Vehicles occupants are assigned to sensors, proportional to the area of the sensor's assigned buildings. Here, we assume that origin has twice as much area as destination.

- To determine number of people who stay in neighborhood (between a pair of sensors)
  - Determine difference between ingress and egress from area
  - Distribute between the two sensors based on available building area in each sensor neighborhood.
  - Use multiplier (1.67) to adjust from vehicles to individuals

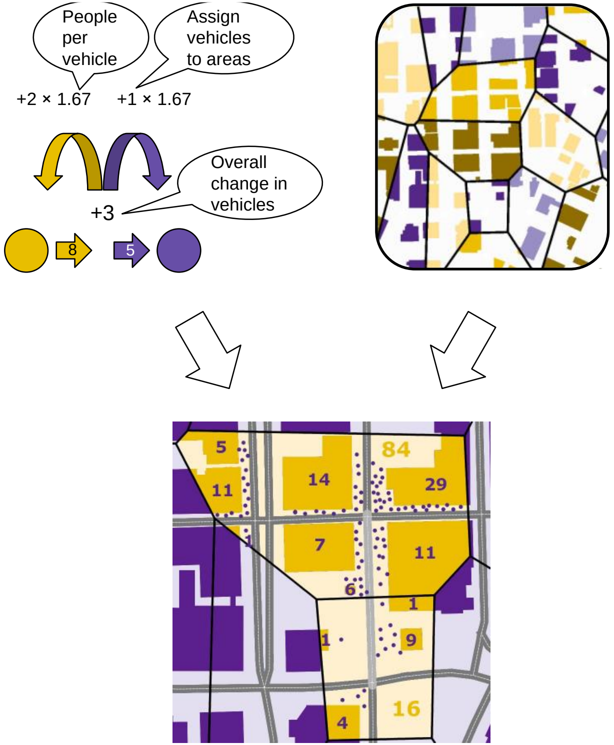
Data-Driven Building Occupancy



- Assign people to buildings which are in the neighborhood of the intersection they were assigned to

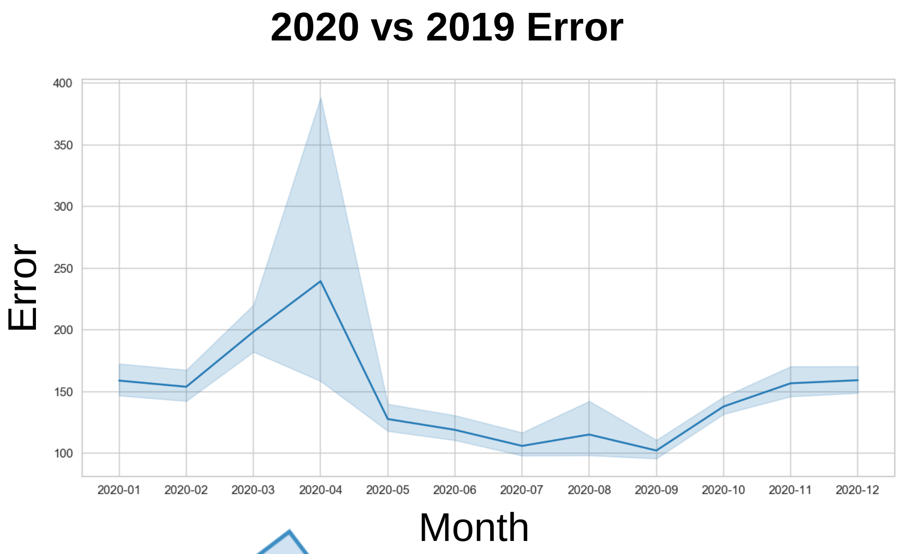
  Aggregate to desired timeframe (hourly, 15 minute, etc)

  Create building occupancy schedules



Vehicle occupants are assigned to buildings in the vicinity of both sensors (gold), proportional to available building space. In this illustration, 100 occupants that arrive in the highlighted road segment between sensors are distributed to nearby buildings by building area.

Results



- Simulated building models
  - with stock occupancy schedules
  - with custom occupancy schedules
- Compared simulated energy use with EPB recorded energy use
  - EPB data: 2019
  - Traffic data: 2020
  - Years were aligned to match week days
- Big error in March and April 2020 aligns with COVID measures in Tennessee

Use Cases

- Real-time data:
  - Operations: When a traffic impact happens (construction, accident, etc), workers could be delayed to work/on their way home. We could then adjust HVAC in response to nearby traffic instead of fixed schedule to save energy.
  - Safety: In case of a disaster, we have a better idea of how many people are actually in the area.

Historic data:

- Currently, we have a custom occupancy schedule for each building for every hour of the year.
- Instead, use average across day-of-week, and maybe season/month for simulations going into the future.
- Could average across stock building types for better stock occupancy schedules.

Future Work

- Validation:
  - Comparison with 2020 energy use (if available)
  - Comparison with ground truth data (if available – e.g. study on ORNL campus)
  - Comparison with other occupancy-like data (e.g. Google popularity curves, SafeGraph, etc)
  - Compare max occupants of residential buildings with Census data
- Data:
  - Integrate more building information (e.g. business hours for restaurants etc)
  - Integrate pedestrians & public transportation data
  - Use real-time data for real-time estimates

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Questions and Comments

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