RM FOR USERS' SAFETY AND SECURITY IN THE BUILT ENVIRONMENT

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OUTLINE

- ► Monitoring the Built Environment
- ► Aggregate Runtime Monitoring
- ▶ Use Cases: Indoor and Outdoor
- ► Deployment of AP on Physical Boards

BUILT ENVIRONMENT

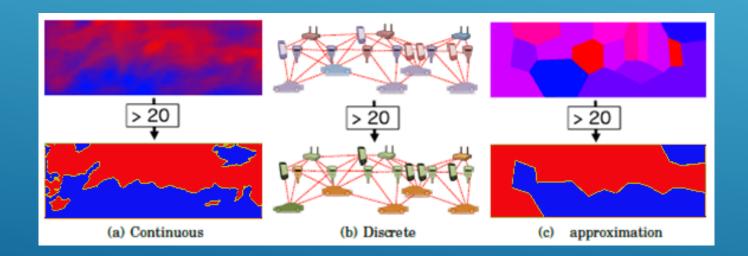
- buildings as services (cognitive buildings)
- ▶ built areas (e.g., construction sites)
- ▶ need for:
 - optimizing comfort conditions
 - managing people flows
 - safety
 - health safety (COVID19)

MONITORING THE BUILT ENVIRONMENT

- deployment of connected fixed/mobile sensors (oT)
- centralized monitoring
 - sensors send info to Intranet/Internet
 - data is analyzed «in the cloud»
 - alarms are sent to users' mobiles
- distributed monitoring
 - critical computation happens at the edge
 - if/when needed info is exchanged with Intranet/Internet

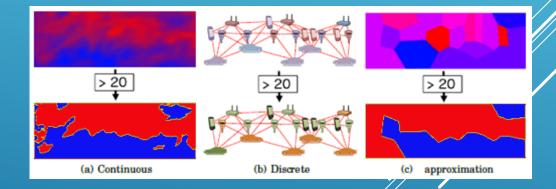
AGGREGATE MONITORING

- use Aggregate Programming system for distributed monitoring
 - Field Calculus minimal functional language for AP



AGGREGATE MONITORING

- use Aggregate Programming system for distributed monitoring
 - Field Calculus minimal functional language for AP
- define properties
 - Past-CTL
 - Spatial Logic of Closure Spaces (SLCS)
 - other?
- ▶ translate to Field Calculus monitors
 - done for SLCS
 - on-going for Past-CTL



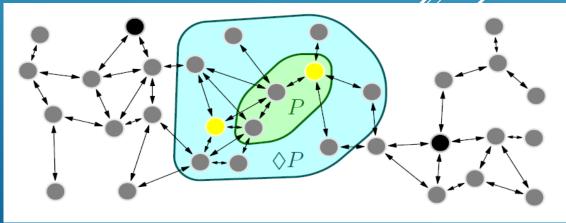
SLCS SMART HOME EXAMPLE (I)

- true on points that are sensing the presence of people;
- D true on points that correspond to monitored electrical device
- 0 true on electrical devices that are on

$$\neg D \lor (O \leftrightarrow \Diamond P)$$

"true on points where (i) there's no monitored electrical device or, (ii) the device is on (0) iff there is some person immediately near it.

♦ local modality closure

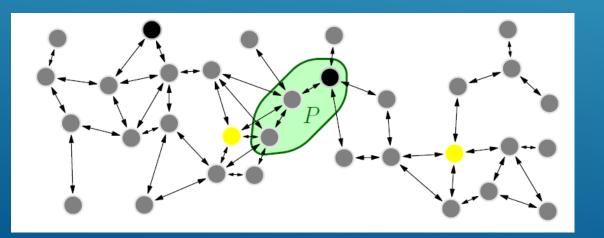


SLCS SMART HOME EXAMPLE (II)

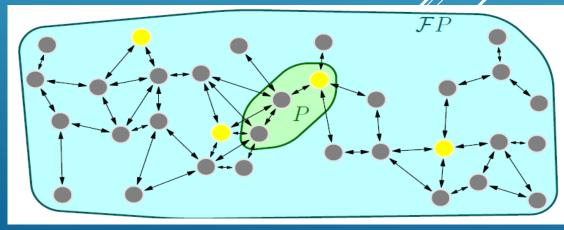
- P true on points that are sensing the presence of people;
- D true on points that correspond to monitored electrical device
- Utrue on electrical devices that are on

$$\neg D \lor (O \leftrightarrow \mathcal{F} P)$$

"true on points where (i) there's no monitored electrical device or, (ii) the device is on (0) iff there is some person somewhere in the building.

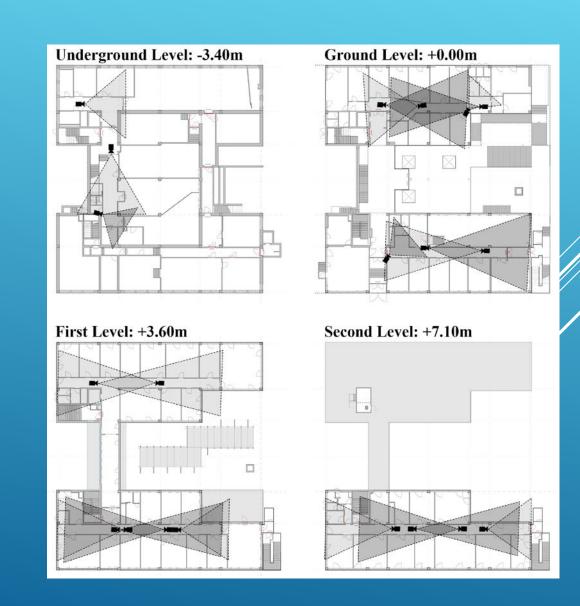


Fglobal modality someh



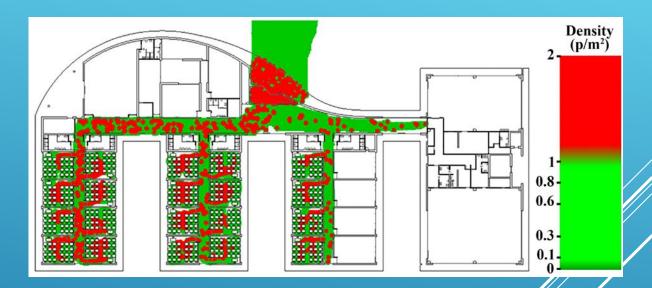
INDOOR USE CASES

- offices building (Milan, Italy)
- ▶ 4 story, 4300 m²
- existing fixed network of cameras for:
 - people counting
- need for:
 - occupancy analysis
 - emergency egress paths
 - social distancing



INDOOR USE CASES

- school building (Melzo, Italy)
- crowd simulations performed on BIM for:
 - occupancy analysis
 - emergency egress paths
- ▶ need for:
 - real-time management VS off-line analysis
 - social distancing



OUTDOOR USE CASE

- construction site (Inveruno, Italy)
- demolition and construction of school site
- ► BIM-based analysis of precast facades:
 - handling
 - ▶ installation
- manual health and safety
- ▶ need for:
 - proximity alerts to workers
 - dangerous areas marking
 - preventing access during loads movement

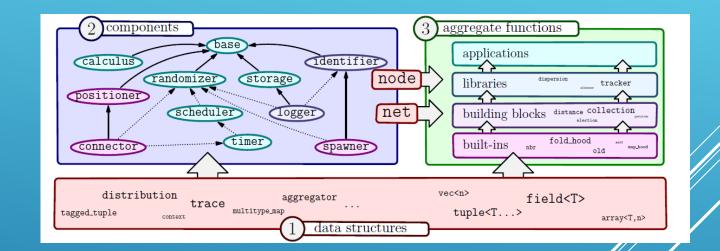


IDEAS FOR OCCUPANCY ANALYSIS (EXAMPLE)

- count the number of people in each room Nr
 - no need for monitor, just a Field Calculus program
 - cross-check with outcome of fixed net
 - rooms not covered by fixed net
 - backup of fixed net
- check that Nr is always less than X
 - simple temporal formula saying that it has never happened that a node has computed Ov = Nr > X = true
- check that there's at least a path to an exit Ex avoiding overcrowded areas Ov
 - simple spatial formula saying that there's a path along which Ov=false ending in a node Ex=true

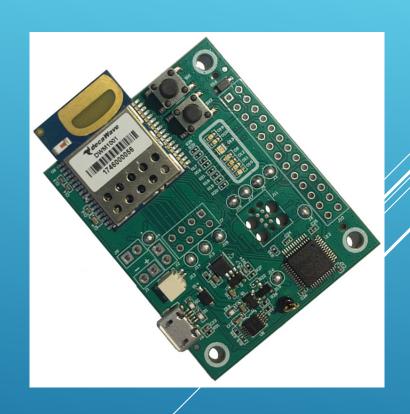
AP ON PHYSICAL BOARDS

- ► FCPP C++14 library
- extensible library:
 - simulation
 - deployment on microcontrollers
 - other scenarios (e.g. HPC)
- ▶ new physical deployment:
 - access physical sensors
 - transceiver interface for the underlying platform the unique id of the devices on the network functions to send and receive data on the network
- ▶ industrial partner Reply



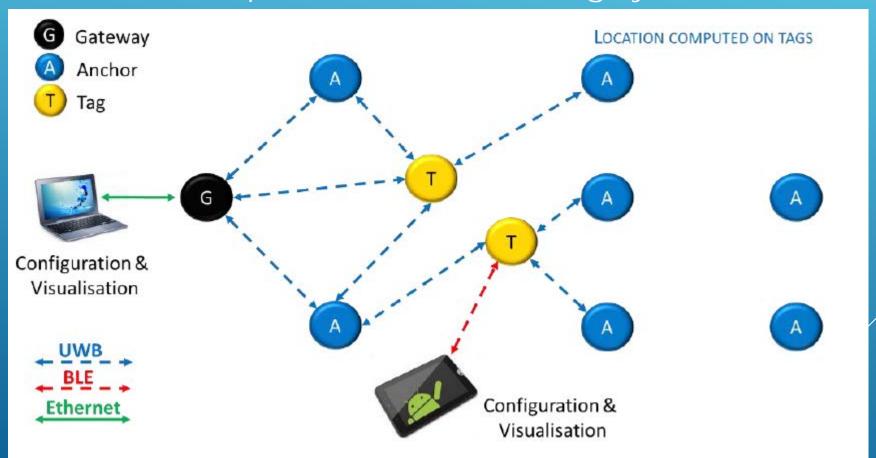
DECAWAVE 1001 DEVELOPMENT BOARD

- ▶ 62mm x 43mm
- ▶ two radio devices
 - Bluetooth Low Energy (BTLE)
 - Ultrawide Band (UWB) transceiver
- ► Nordic nRF52832 chip
 - ► ARM Cortex-M4 CPU
 - ► 512kB flash memory
 - ► 64kB RAM
- measures ranging accuracy to within 10cm
- can act as gateway to Ethernet



DECAWAVE 1001 DEVELOPMENT BOARD

Example: Real Time Locating System



CONTIKI NG OS

- ▶ OS for resource-constrained devices
- ▶ memory usage can be just 10 kB
- supports proto threads (i.e. no preemption)
 - need to adapt FCPP
- experimental toolchain for C++ development
- stack IPV6 for Internet/Intranet communication

ROADMAP

research and development

translation of Past-CTL into Field Calculus mixing temporal and spatial logics implement translation

experiments

define relevant logic properties for the Use Cases
translate to Field Calculus monitors
deploy on DECAWAVE boards
experiment with real users in the UC built environments

THANK YOU