Mobile Node Rostering In Intermittently Connected Passive RFID Networks

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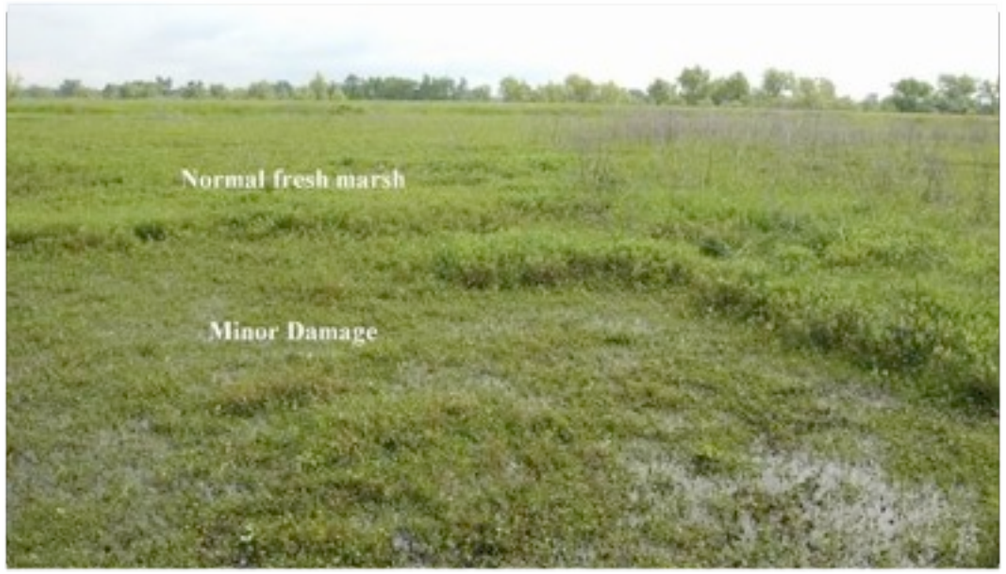
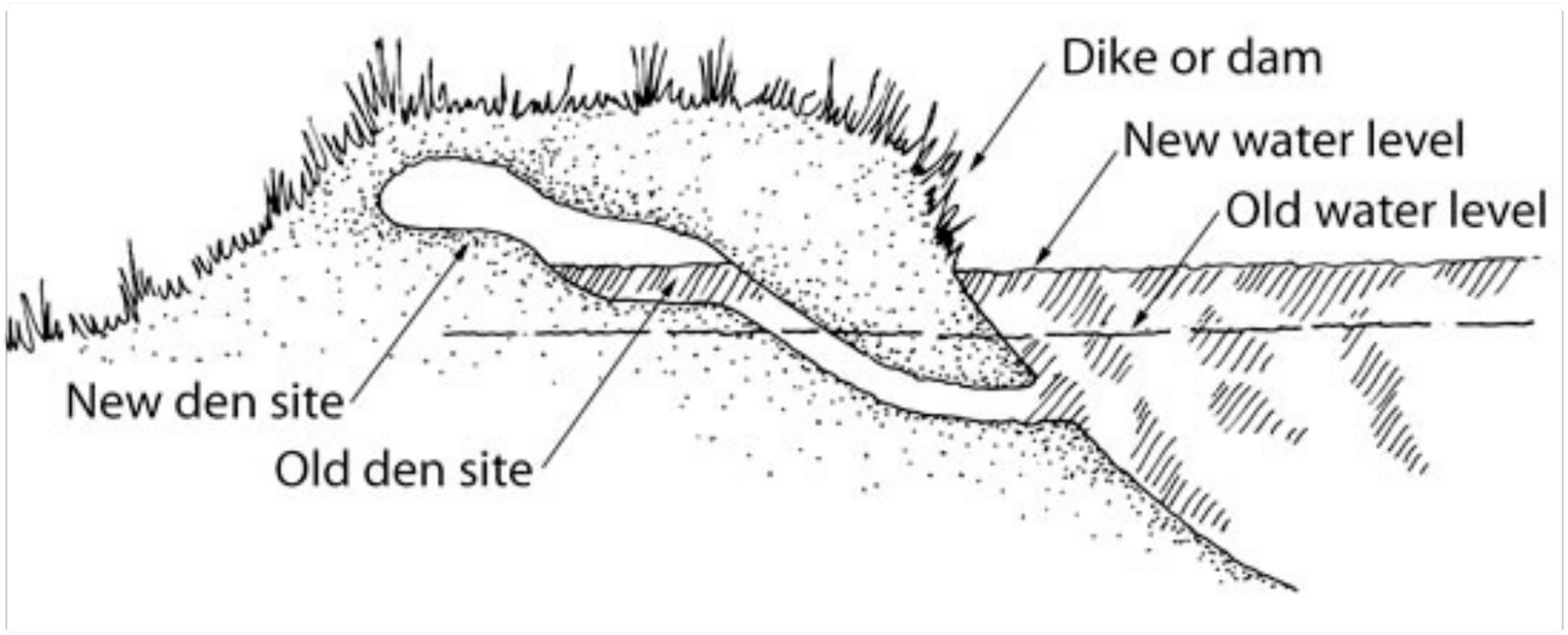
OUTLINE

- [ ] MOTIVATION
- [ ] SYSTEM ARCHITECTURE
- [ ] PROBLEM DESCRIPTION
- [ ] PROPOSED ROSTERING ALGORITHM
- [ ] IMPLEMENTATION AND EXPERIMENTS



Biological Research at National Wetlands Research Center

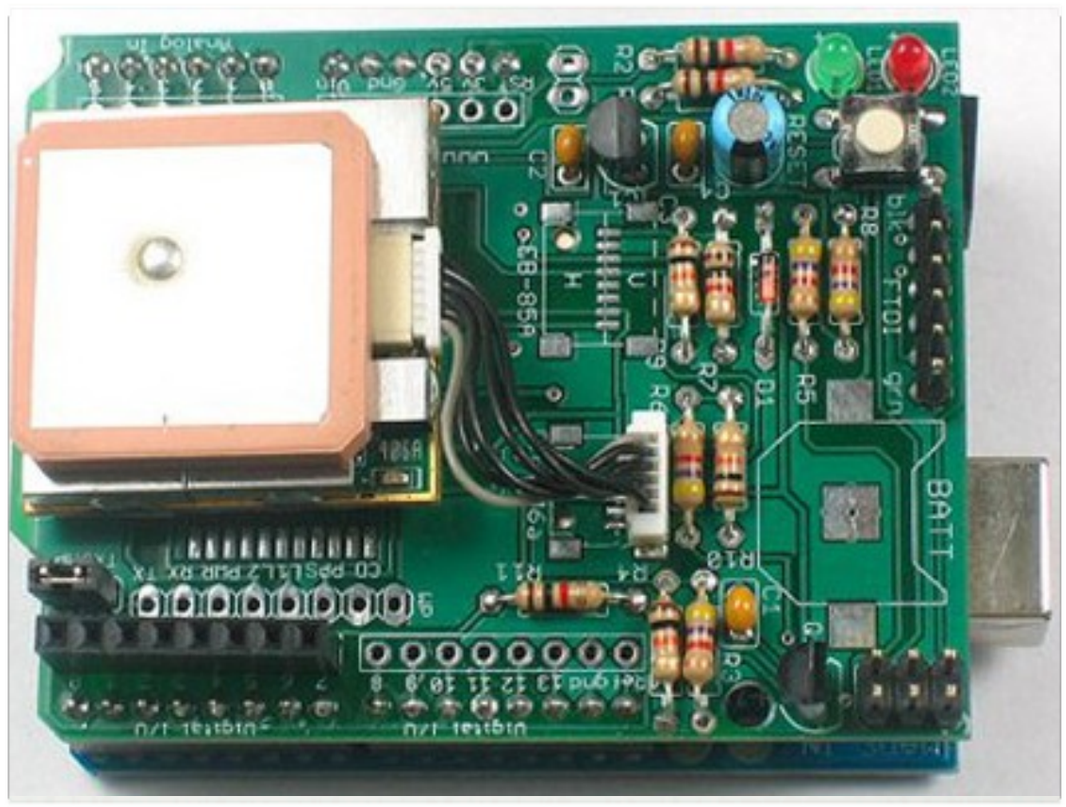


Damages made by nutria

WHAT WE SHOULD DO

- [ ] Observe many problems caused by nutrias
- [ ] Track them
- [ ] Understand their habitat
- [ ] Build models to predict their behavior, population, and potential damage
- [ ] Develop strategies to control them and protect our property

MICAz



GPS

Wireless sensor network and GPS technologies have been explored for wildlife research

What we do in field experiments ……

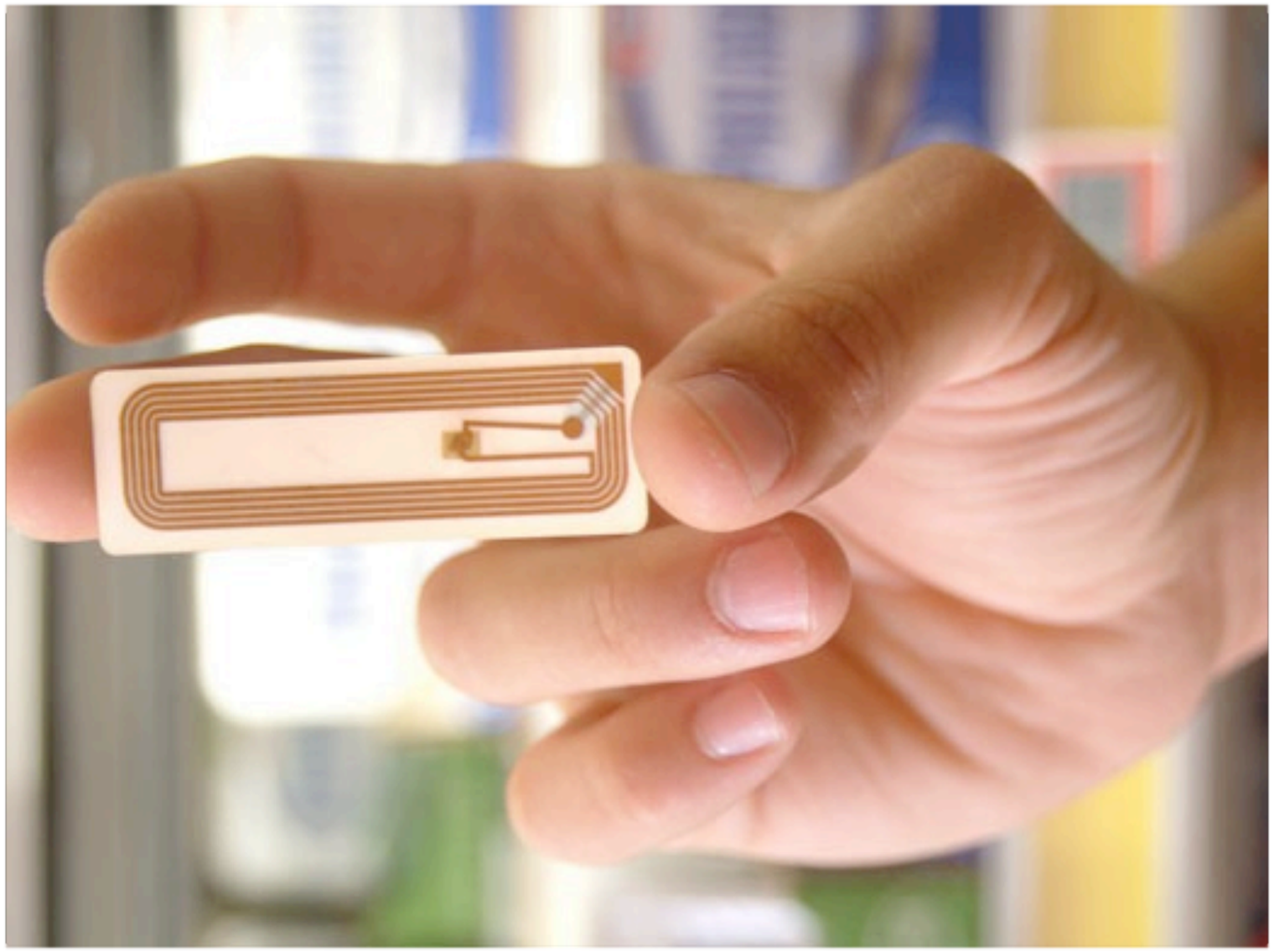
Mark it, attach GPS, let it go ....

Days later ....

DEAD!

LESSONS LEARNT

- Weight constraint
  - the weight of the sensor must be under 5% of the weight of the animal to avoid hindering its movement or welfare
- The lowest weight of active device is bounded by
  - battery: to power the device
  - casing: must be heavy-duty for the protection of power source and powered electronic circuits under harsh environments
  - 80% of the nutria cannot carry any active devices
- Similar problems for most small animals
  - frog migration, penguins habitat tracking, ...



POSSIBLE SOLUTIONS

Passive RFID Tags

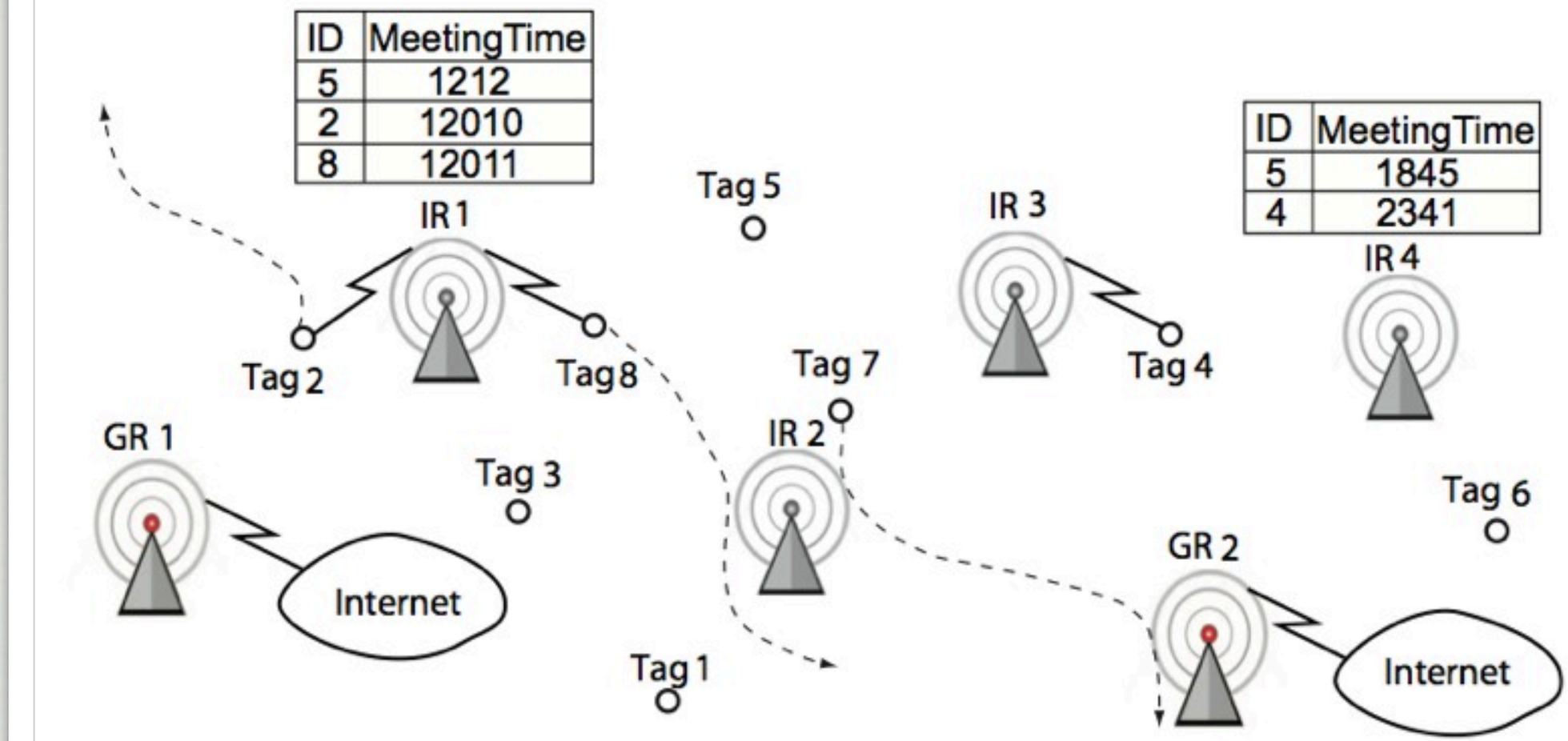
PASSIVE TAGS

- [ ] Nice properties
  - [ ] No battery
  - [ ] No need for casing
  - [ ] very thin and light (less than 1 gram)
  - [ ] Low cost
  - [ ] Durable: survivable under very harsh environments (underwater, underground tunnels, and extreme temperatures)

POSSIBLE SOLUTIONS

Passive RFID Tags on Nutria

How to build an independent network based on RFID gears for data delivery in a remote area without any infrastructure support?



ARCHITECTURE OF FINDERS

IR: Isolated Reader GR: Gateway Reader

UNIQUE CHALLENGES

- Intermittent connectivity:
  - The connectivity of FINDERS is very low and intermittent, forming a sparse network where a tag is connected to a reader only occasionally.
  - A special DTN with unique communication and storage constraints.
- Intermittent computation:
  - The computation at the tag is also intermittent. It is available only when the tag is powered up by a nearby reader.
  - Such continuous functions necessary to many protocols as counters and timers cannot be implemented here.

UNIQUE CHALLENGES

- Critical network resource:
  - the buffer space of the tags (the main vehicle for data transportation) is so limited that it may become the critical network resource and communication bottleneck
- Nodal heterogeneity:
  - a reader is a static and powerful device, with large storage, high computing power, and long-lasting battery power
  - the tag can be mobile and has extremely limited resource
- Asymmetric communication:
  - The communication can be established between a tag and a reader only, but not tags to tags or readers to readers

MORE ON FINDERS:

Zhipeng Yang and Hongyi Wu,
"FINDERS: A Featherlight Information Network With Delay-Endurable RFID Support",
[Journal Version] IEEE/ACM Transactions on Networking, 2011.
[Conference Version] IEEE SECON, 2009.
[NSF Project Proposal] NeTS, 2008.

PROBLEM OF ROSTERING

- Rostering is a pervasive computing problem, aiming to enable a user to access the distributed local meeting tables and aggregate their meeting events to report a list of the mobile nodes that appear in given area(s) and time interval(s).

```
SELECT tagID
FROM MeetingTable
WHERE timestamp > begin time
AND timestamp < end time
AND readerID > 'id1'
AND readerID < 'id2'
```

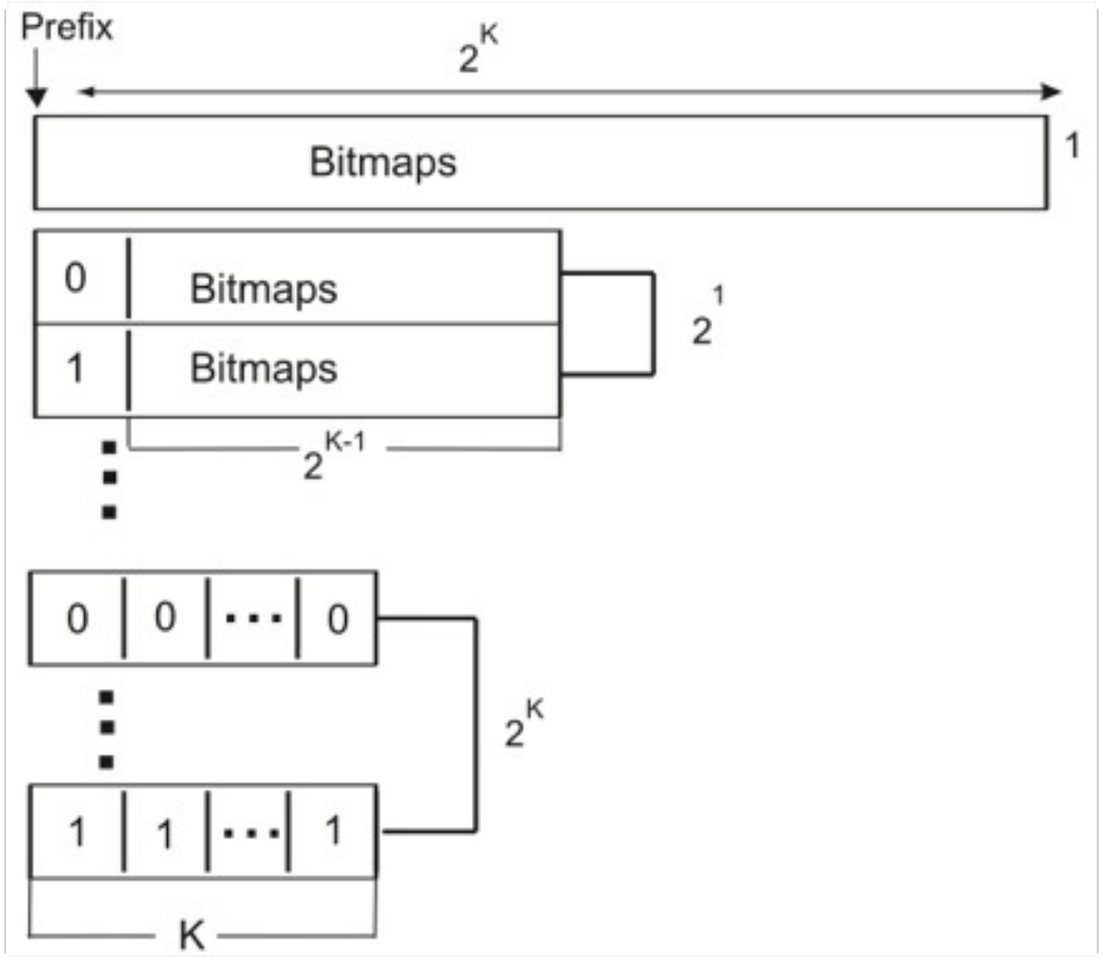
OBJECTIVES

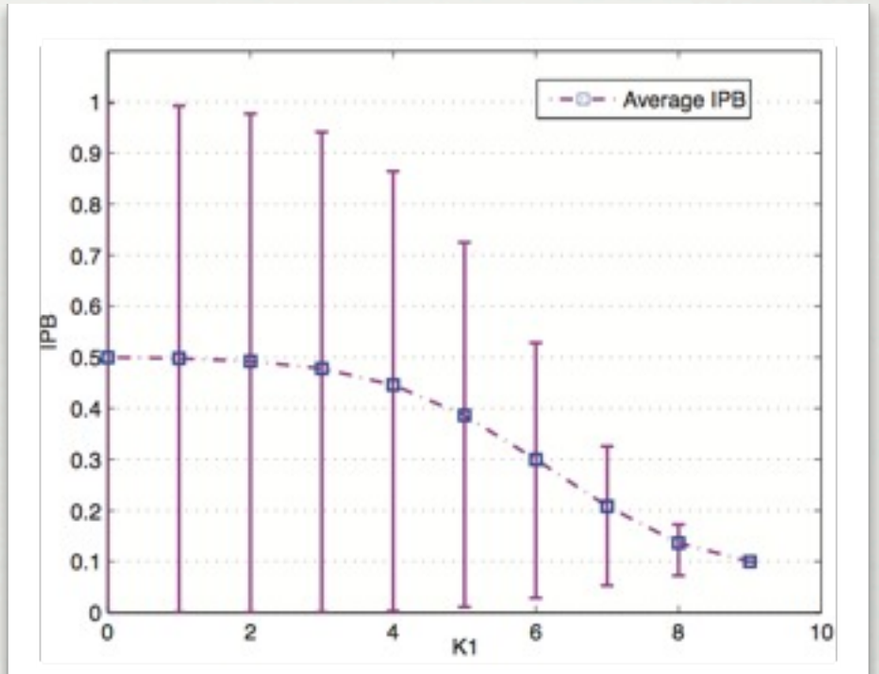
- ☐ Devise a distributed algorithm to choose the best set of packets according to information redundancy and tag mobility, aiming to maximize their total information value and at the same time do not exceed the capacity of a tag.
  - ☐ Storage Constraint: Data packets must bear a compact format, which is tailored for adaptive data aggregation in rostering.
  - ☐ Redundancy: Part of the data maintained by different readers can be redundant for a given rostering request.
  - ☐ Mobility: Mobile nodes with different mobility patterns are suitable for carrying different packets

ROSTERING ALGORITHM

- Three type of Messages to support Rostering
  - Command Packet: a rostering command is issued by a GR.
  - Reply Packet: zero to multiple Reply packets may be created by an IR, in response to a rostering command
  - Feedback Packet: one or multiple Feedback packets are generated by a GR, corresponding to a command.

ANALYTIC RESULTS





- Goal: To let the tags carry the most valuable information in a capacity-efficient way to the GRs

APPRAISAL AND SELECTION OF HYPOTHETIC PACKET CANDIDATES

- The reader must choose a subset of them with the highest value for transmission.
- Such optimization is formulated as a 0-1 Knapsack problem

$$Maximize \quad : \quad \sum_{i=1}^{n} v_i x_i$$

$$Subject\ to \quad : \quad \sum_{i=1}^{n} w_i x_i \leq W,\ x_i \in \{0, 1\}$$

APPRAISAL AND SELECTION OF HYPOTHETIC PACKET CANDIDATES

- Appraisal of Reply and Feedback Packets

$$v_i = \sum_{j=1}^{c_i} u_j$$

$$u_j = P_1(1-\eta_1)^{\lfloor \frac{t-t_j}{\Delta} \rfloor}/m_j$$

- Appraisal of Command Packets

$$v_i = P_2(1-\eta_2)^{\lfloor \frac{t-t_i}{\Delta} \rfloor}/m_i$$

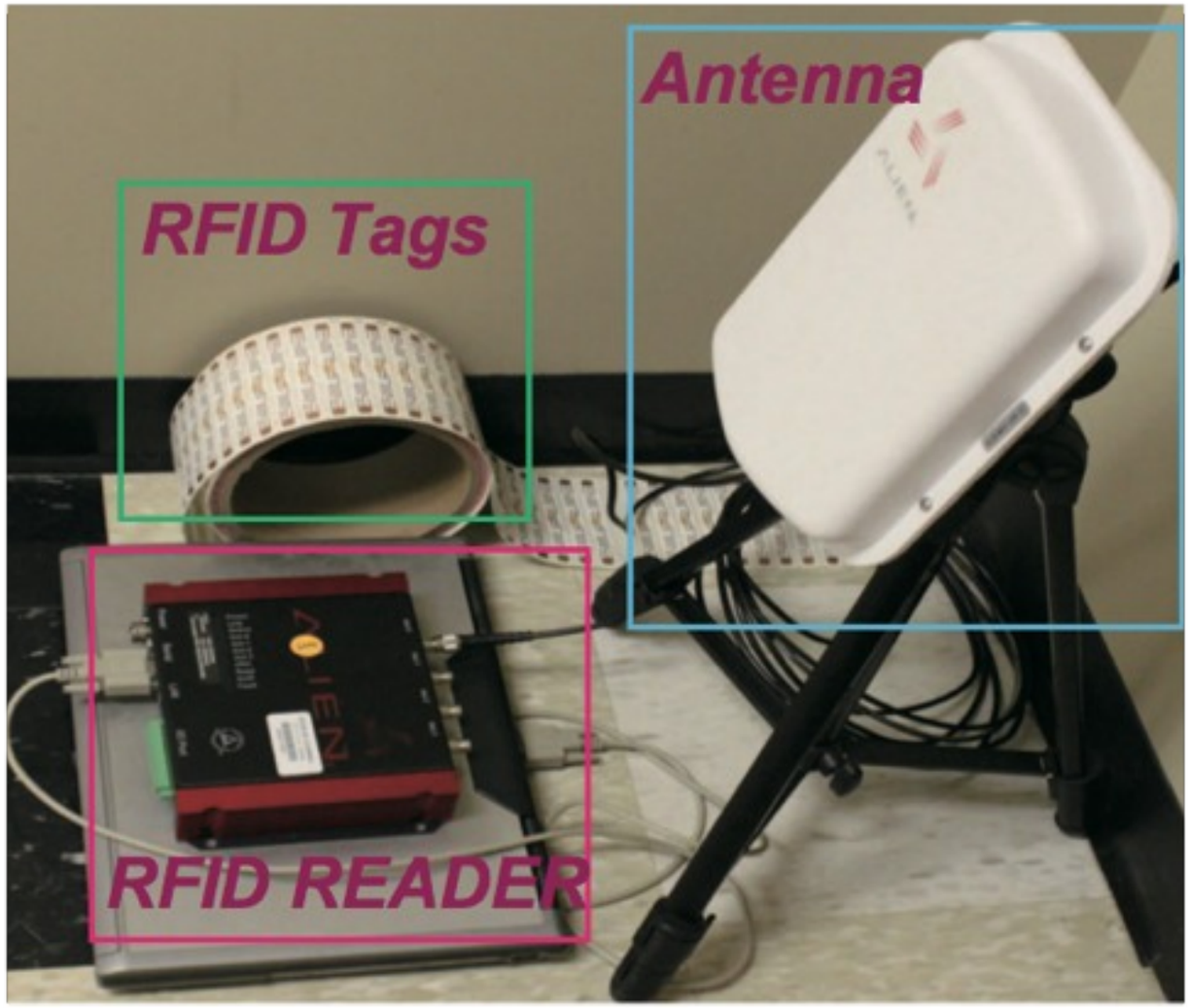
APPRAISAL AND SELECTION OF HYPOTHETIC PACKET CANDIDATES

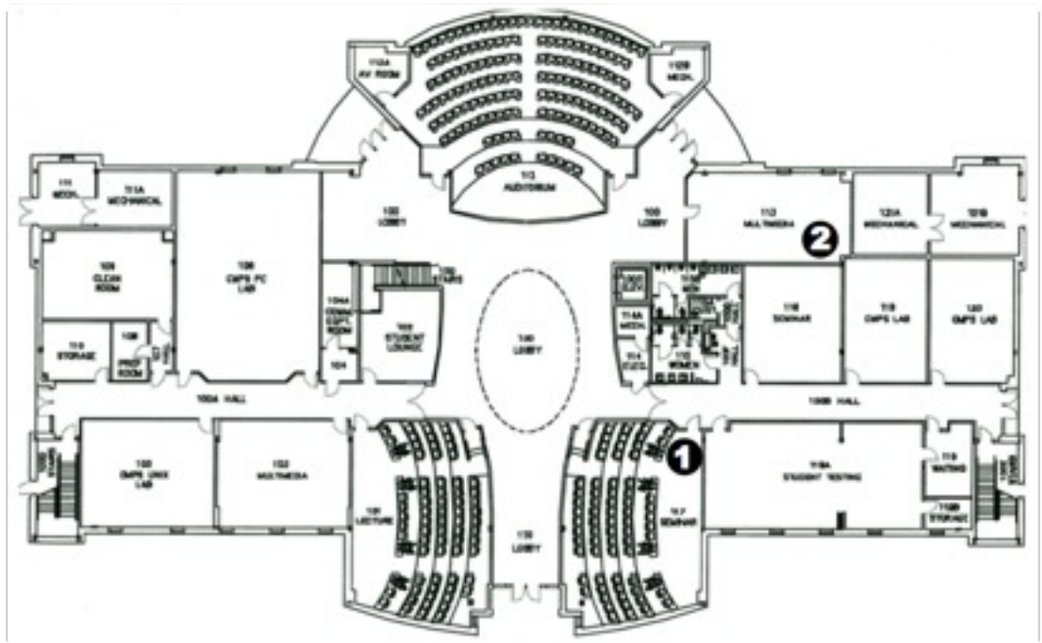
- ☐ Effective Delivery Capability (EDC) to reflect the node's cascaded probability to "reach" GR's.
  - ☐ GR: 1
  - ☐ IR/Tag: initialized as 0 and updated by EWMA
- ☐ Appraisal Adjustment: (Reply Message)

$$\tilde{v}_i = \begin{cases} \max(\beta_1 \frac{\xi_{tag}}{\xi_{IR}}, \beta_2) v_i, & \xi_{IR} < \xi_{tag} \\ \min(\beta_1 \frac{\xi_{tag}}{\xi_{IR}}, \frac{1}{\beta_2}) v_i, & \xi_{IR} \geq \xi_{tag} \end{cases}$$

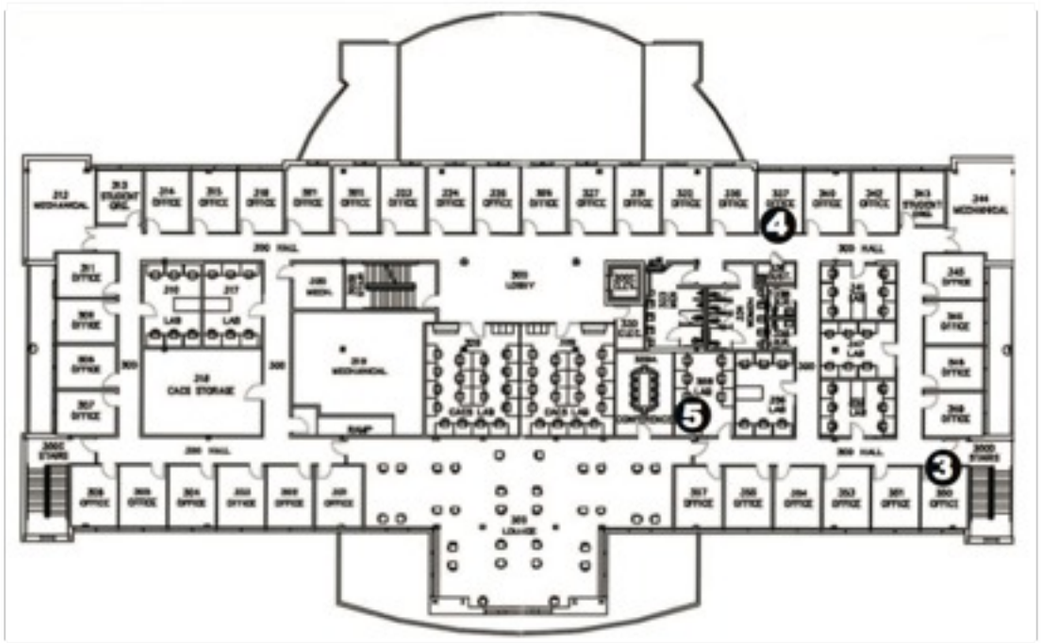
RFID GEARS

- Alien passive RFID tags (ALN-9540)
  - Class1Gen2
  - 8.15 × 94.8 × 0.05 mm
  - Less than one gram
  - 14 bytes
- ALR-9900 readers
  - 64 MB RAM
  - 64 MB flash memory
  - 4 antennae and 50 channels





1ST/2ND FLOOR

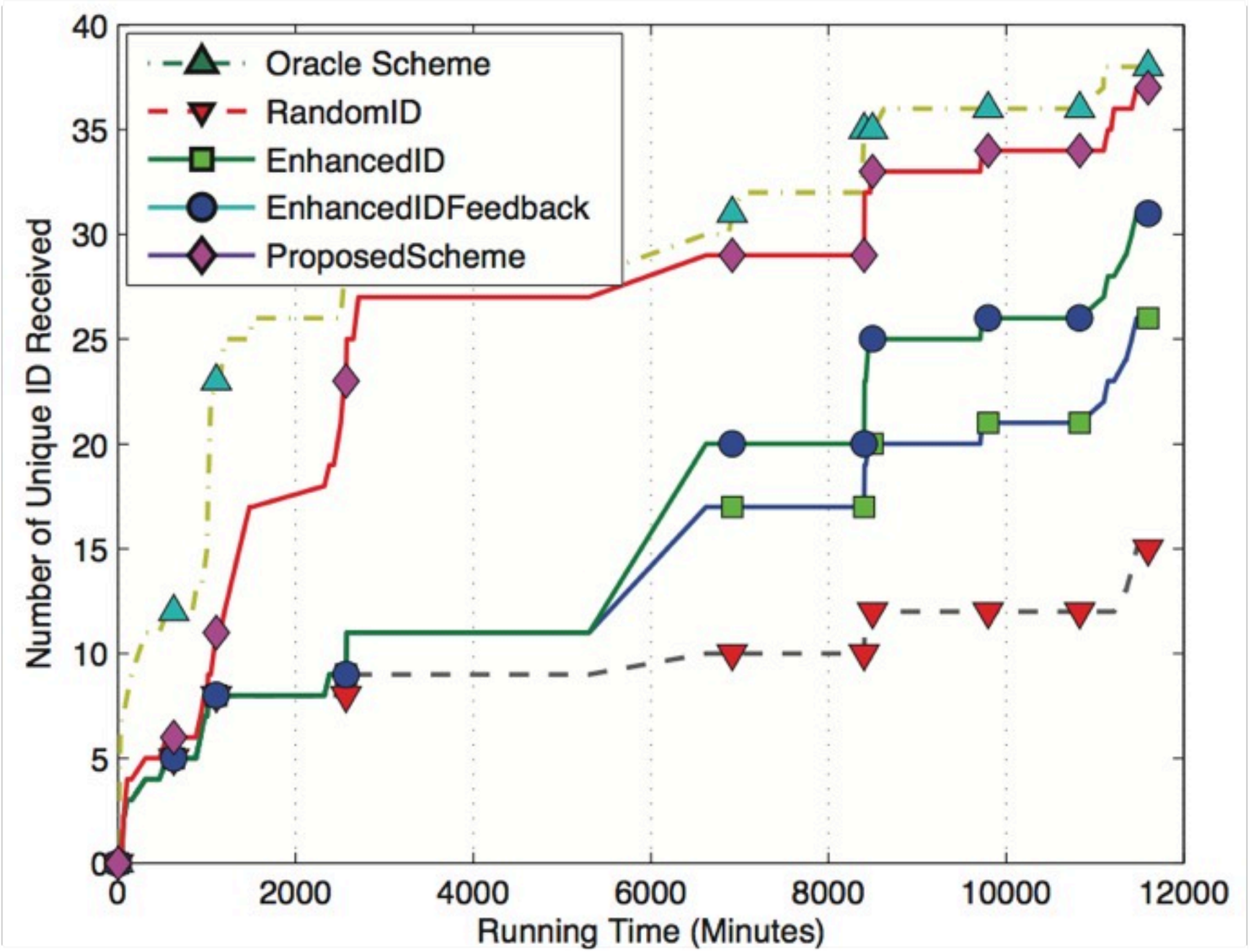


3RD FLOOR

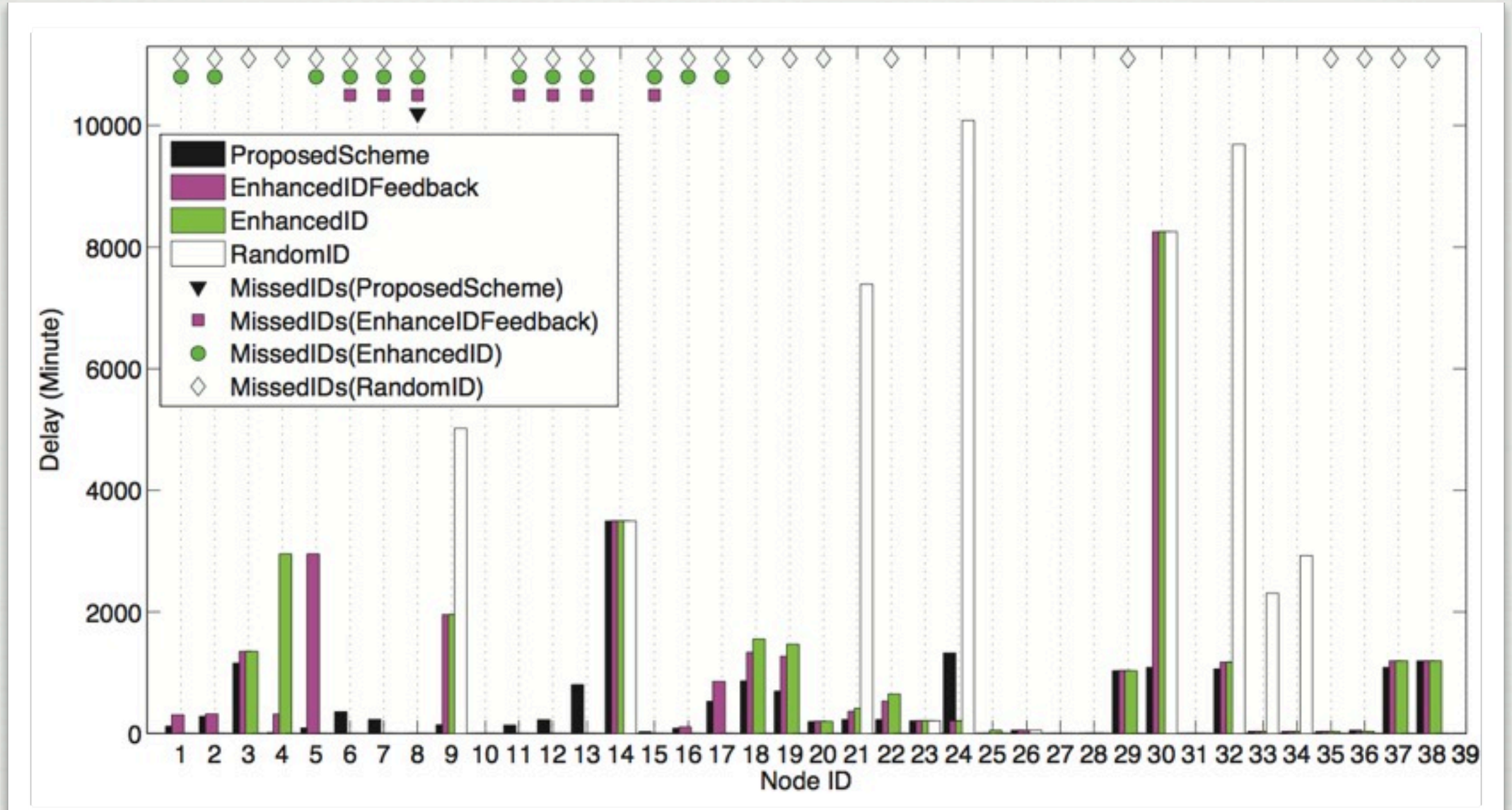
PARTICIPANTS: 38 STUDENTS & PROFESSORS

DURATION: 9 DAYS

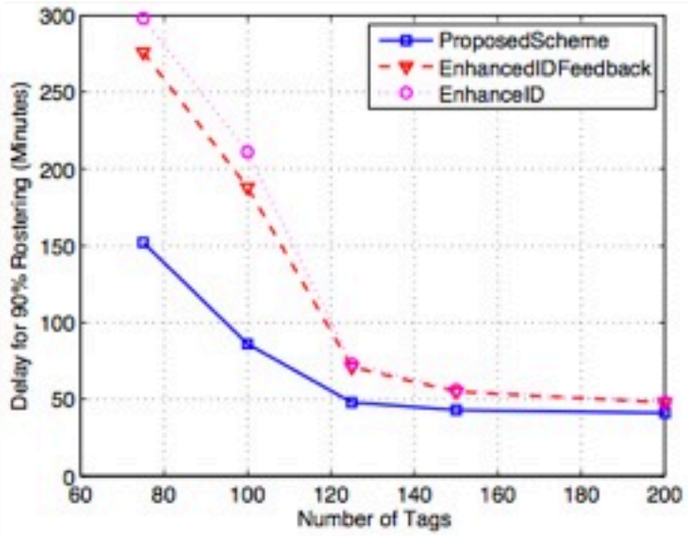
EXPERIMENTAL SETUP



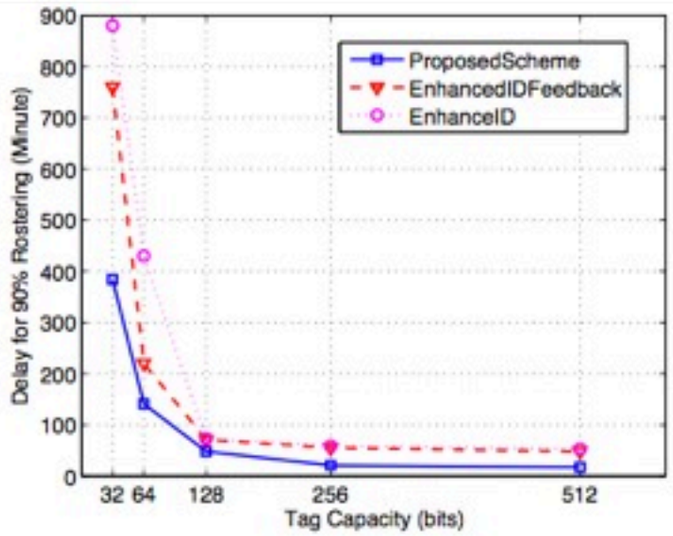
Rostering Efficiency



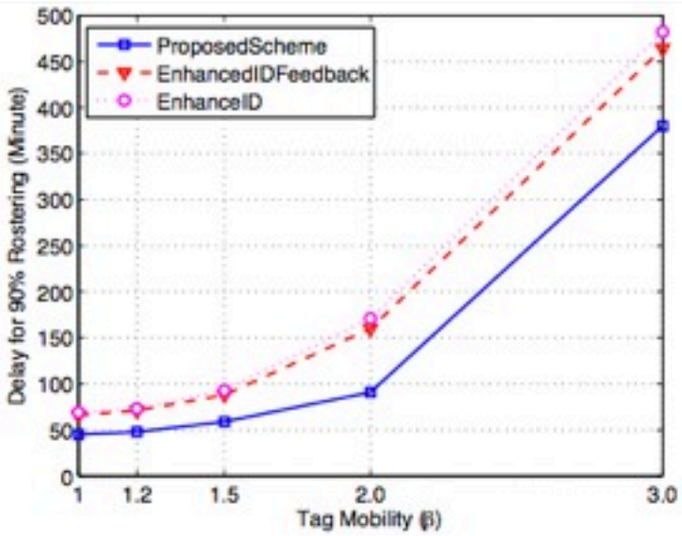
Delay Distribution



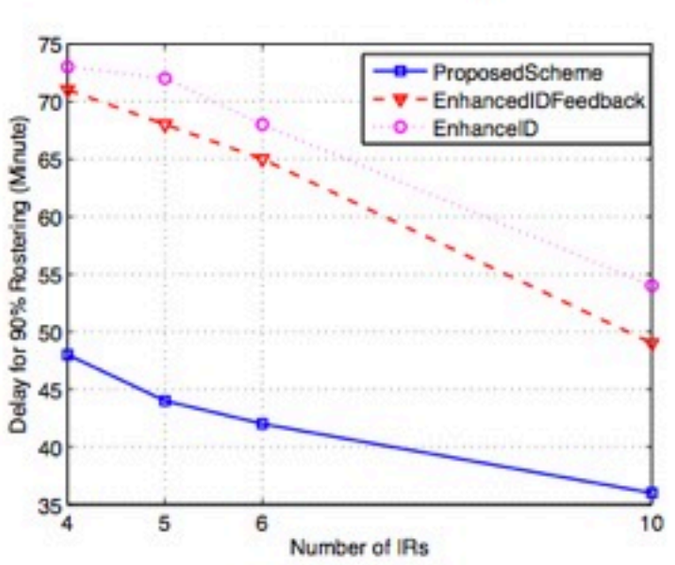
(a) Number of Tags.



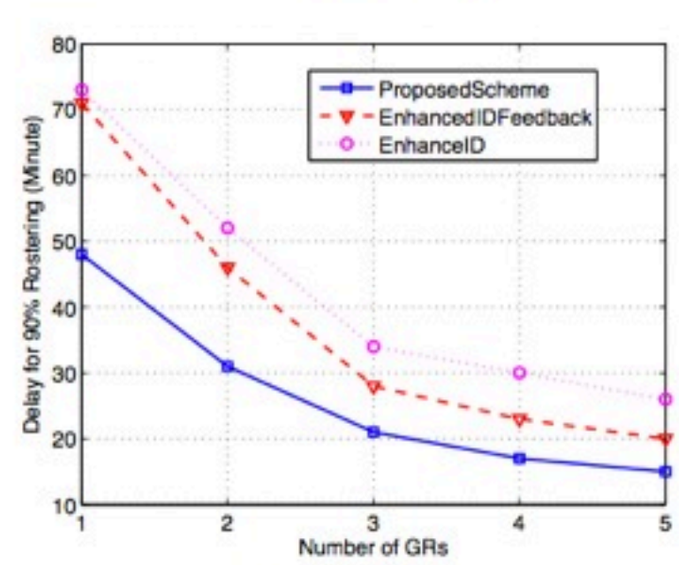
(b) Tag capacity.



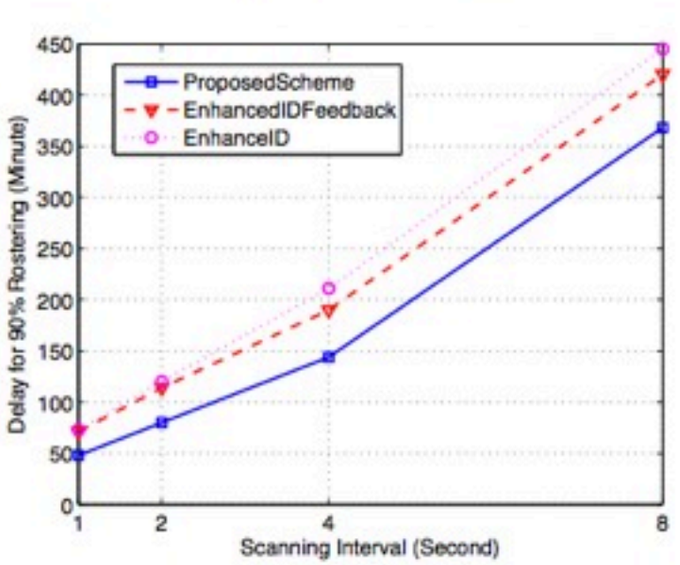
(c) Tag mobility.



(d) Number of IRs.

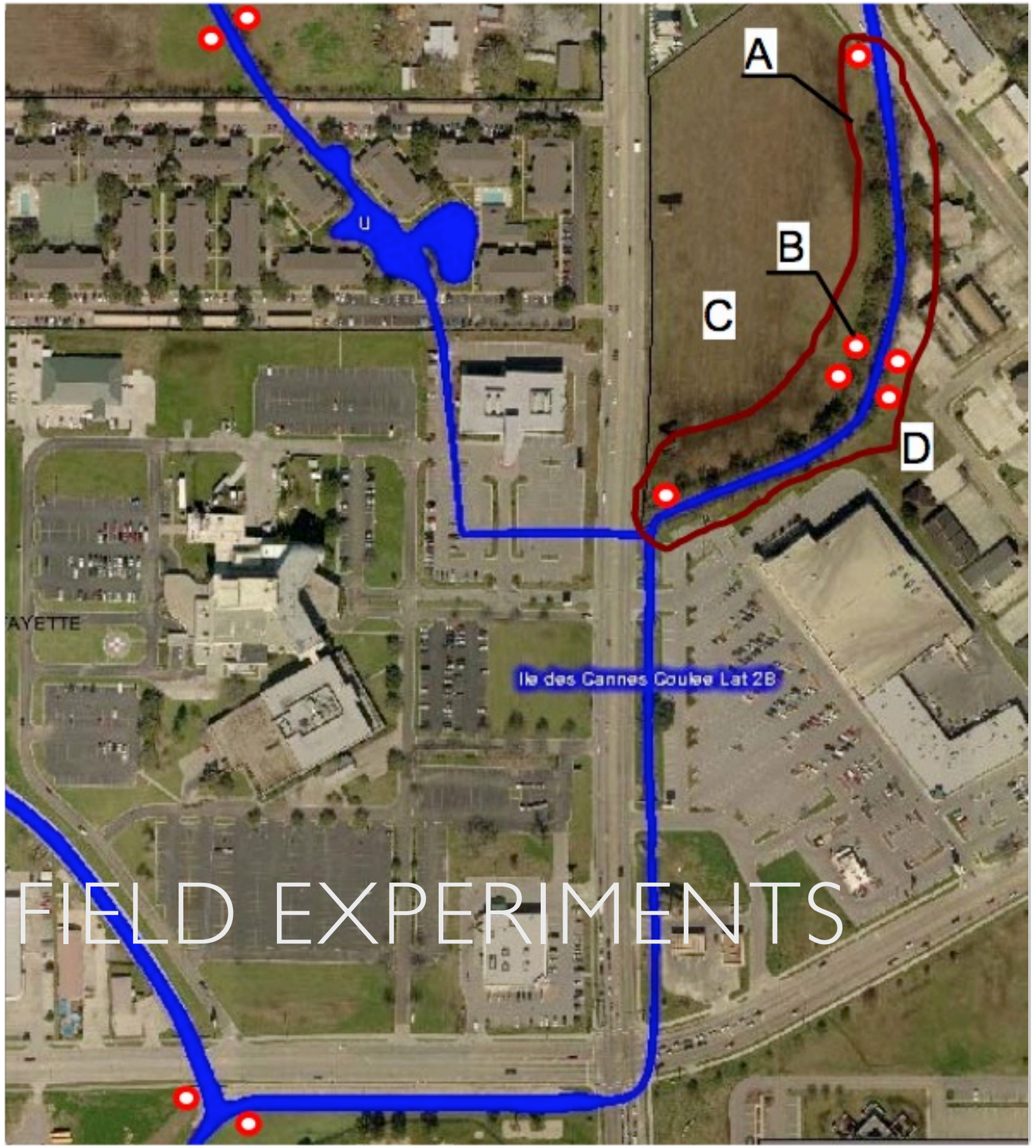


(e) Number of GRs.



(f) Scanning Interval.

Simulation Results



PLANNED FIELD EXPERIMENTS

SUMMARY

Motivation: Weight Constraint

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Solution: Passive RFID Tags

↓

Challenges: Limited Resource

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Contribution: Protocol Development

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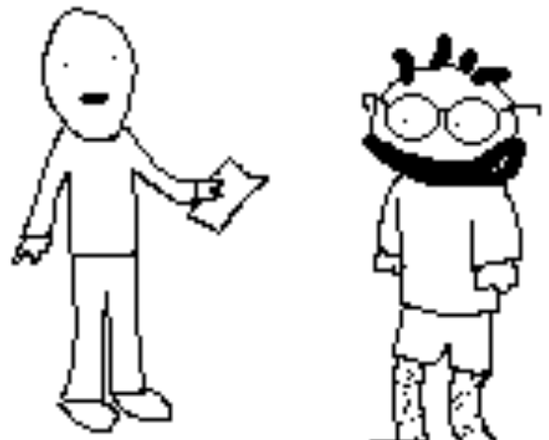
Evaluation: Implementation and Experiments

Your answer to Question 3 was far too specific. You must be more vague. Try to generalize a little more. I recommend overusage of the word "generally."



QUESTIONS ?