Swarm Intelligence (SI)

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Classical Computation

Classical computing is good at:

- Rule-based reasoning
- Constant repetition of *well-defined* actions.

Classical computing is bad at:

- Robustness to damage
- Dealing with vague and incomplete information;
- Adapting and improving based on experience

Why is SI interesting for IT?

- Distributed system of interacting autonomous agents
- Goals: performance optimization and robustness
- Self-organized control and cooperation (decentralized)
- Division of labor and distributed task allocation
- Indirect Interactions

Swarms Which Inspired Researchers

- Ant Colony
- Termites
- Bees
- Flock of Birds
- School of Fish
- …..

Ants and Termites

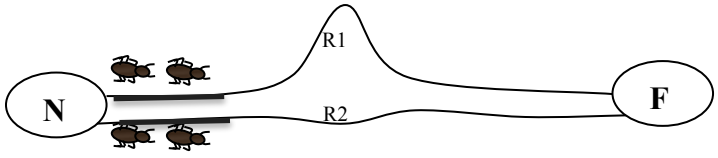
- Use concept of *stigmergy*, a form of indirect communication, for their coordination.
- Through a chemical substance called *pheromone* the stigmergy is achieved.
- Work in two phases
  - A non-coordinated phase
  - Coordinated phase.

Ant Colony Algorithm / Termite Algorithm

- Inspired by the foraging behavior / hill building nature.
- Each node will have a pheromone table.
    - List of neighbors and destinations it can reach
- When packet arrives pheromone is updated by some constant.
- Pheromone will decay over fixed period.
- Each link will have a probability of being used, per packet routing protocol

Four Principles

- *Positive Feedback*
- *Negative Feedback*
- *Randomness*
- *Stigmergy*



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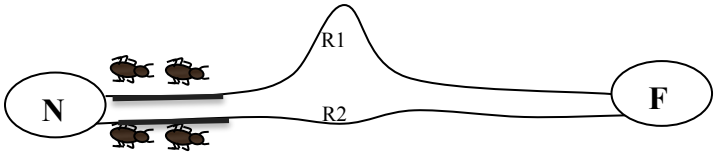

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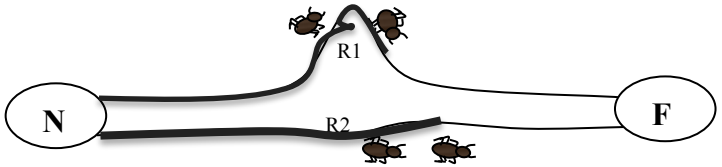

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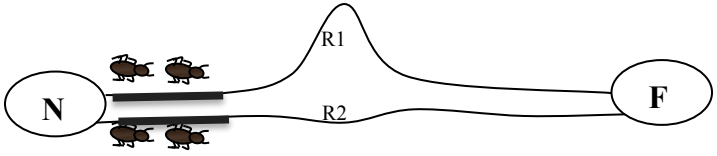

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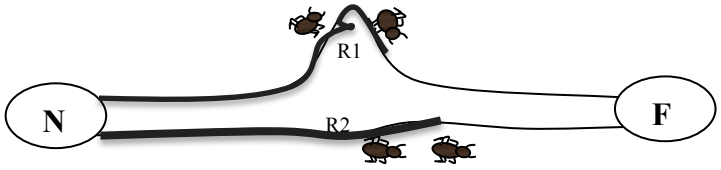

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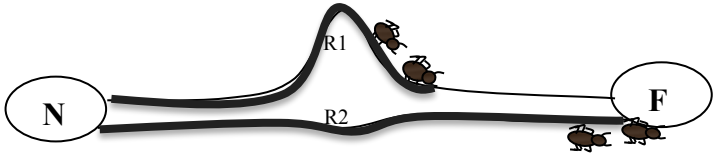

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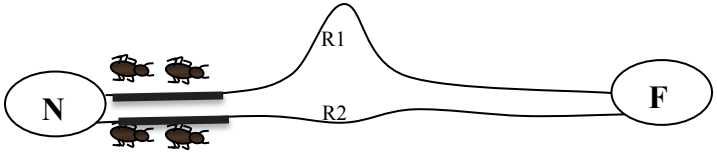

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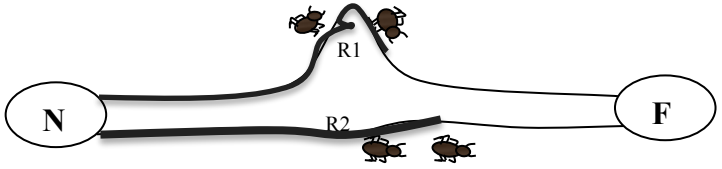

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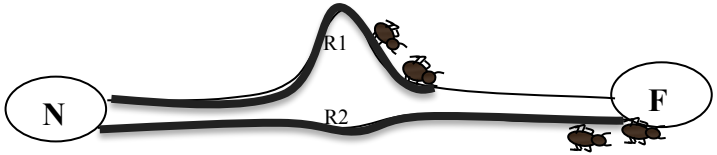

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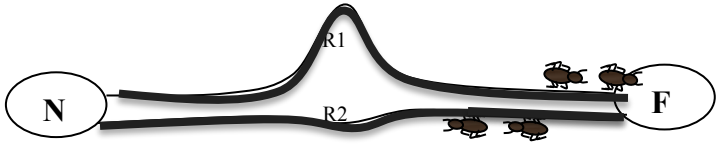

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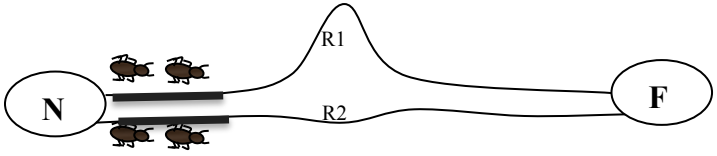

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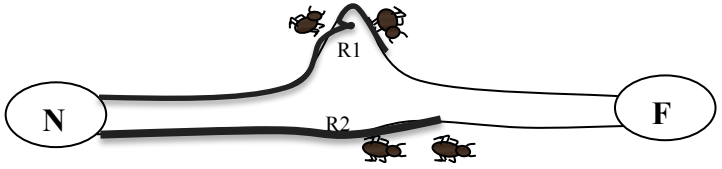

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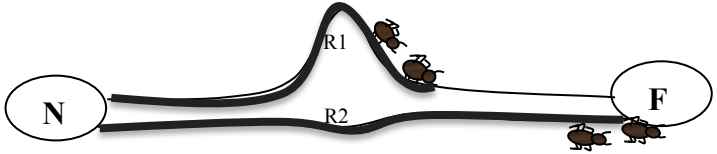

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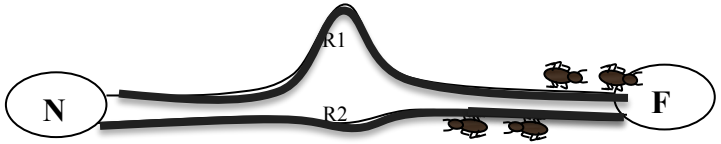

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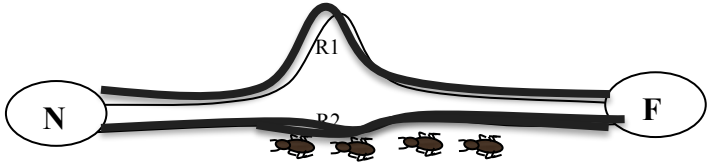

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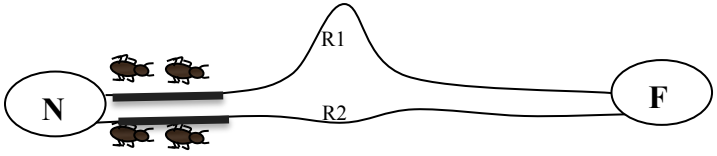

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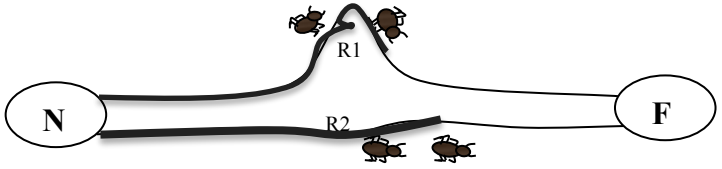

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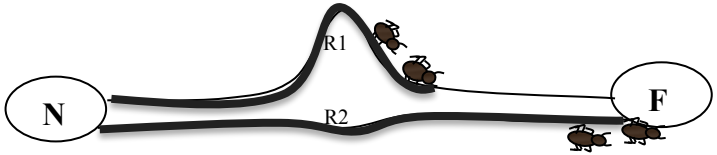

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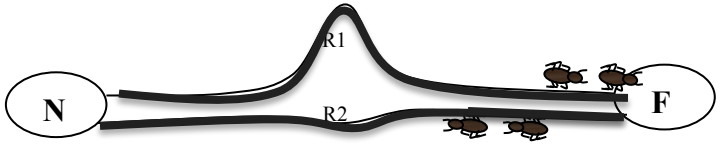

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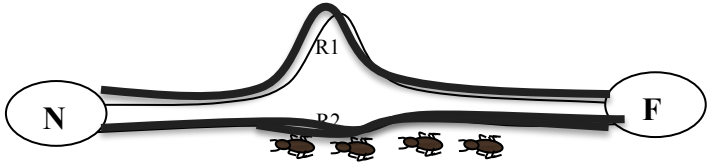

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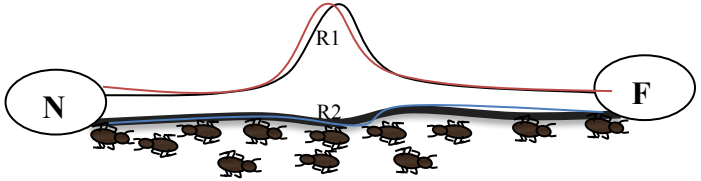

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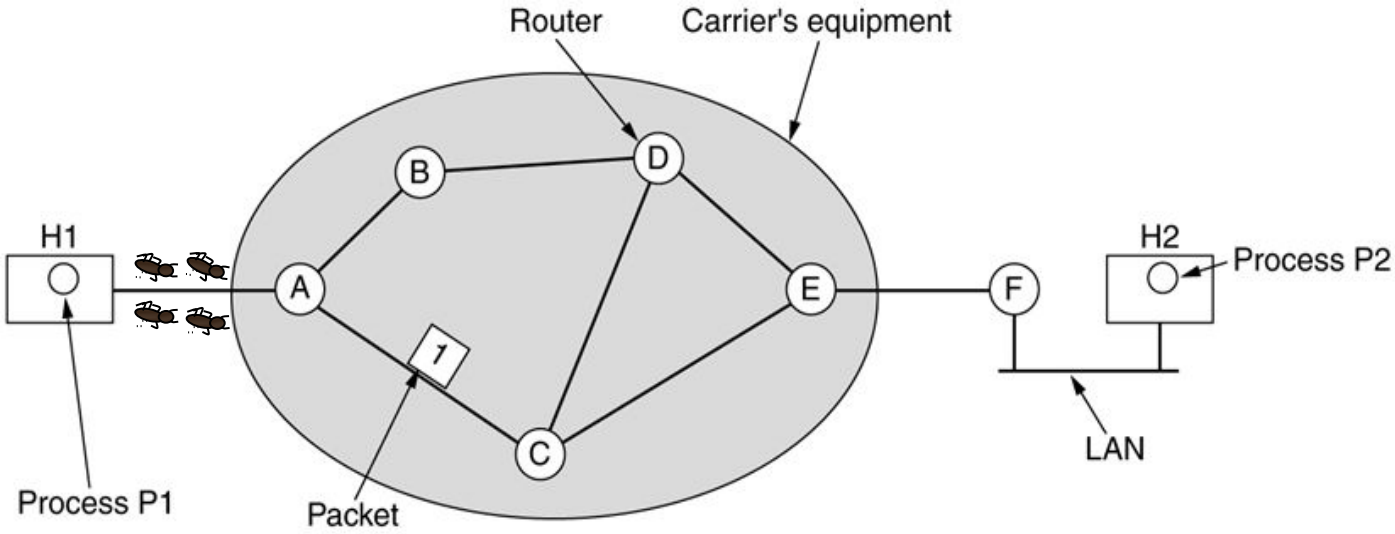
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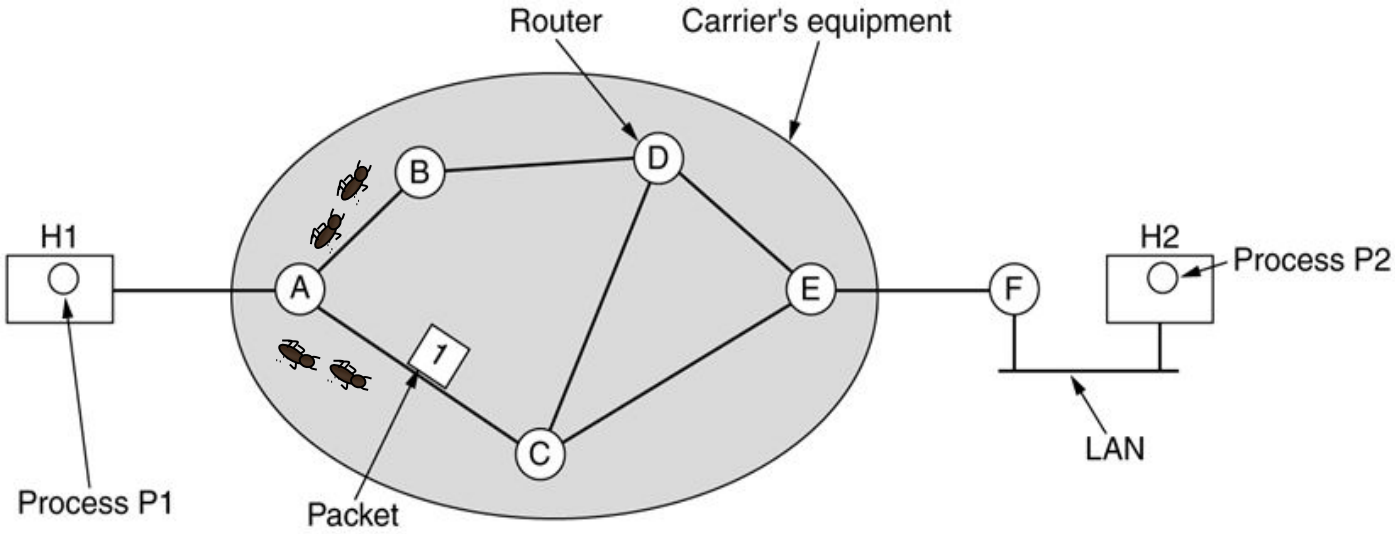
Carrier's equipment
B
D
H1
H2
Process P2
A
E
F
1
C
LAN
Process P1
Packet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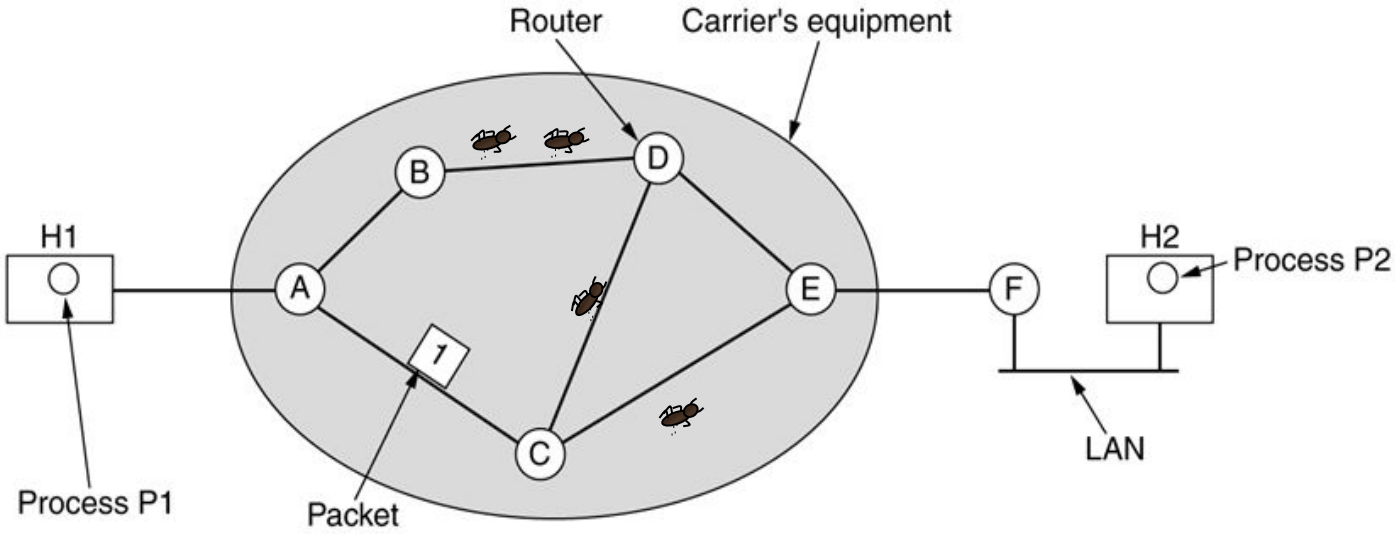
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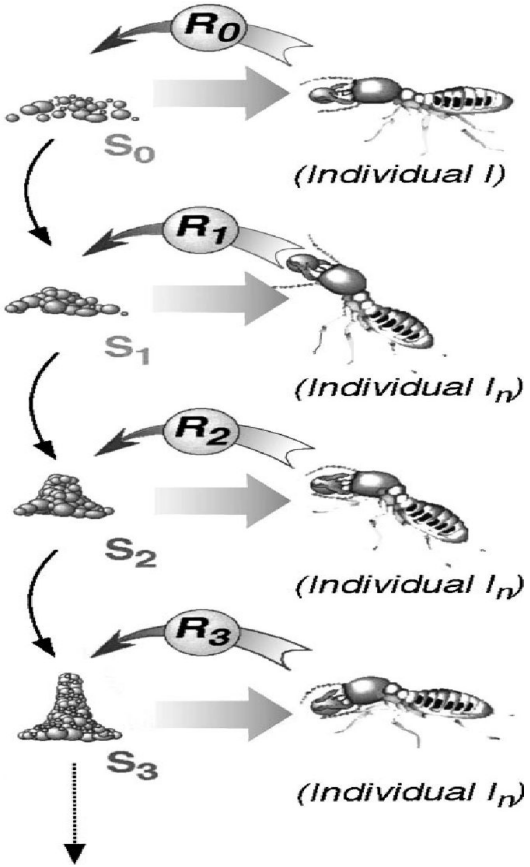
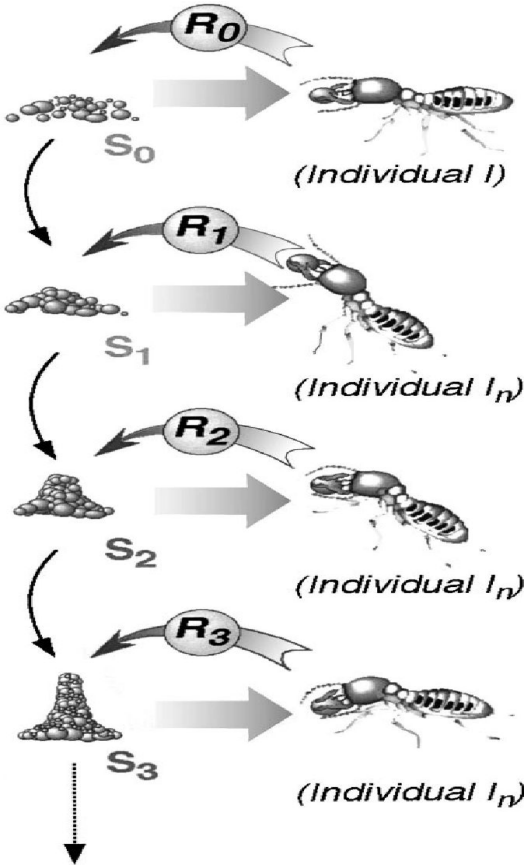


Hill Building Nature of Termite

Start



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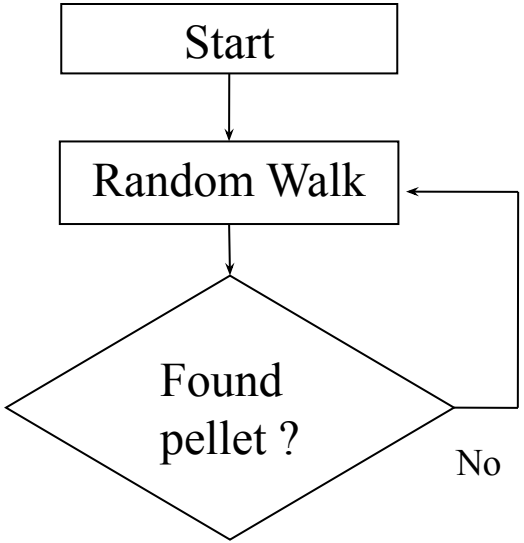

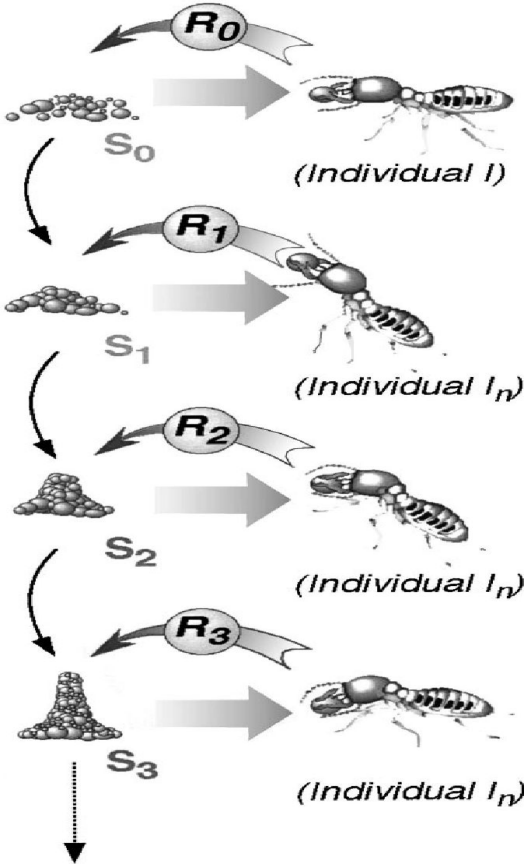

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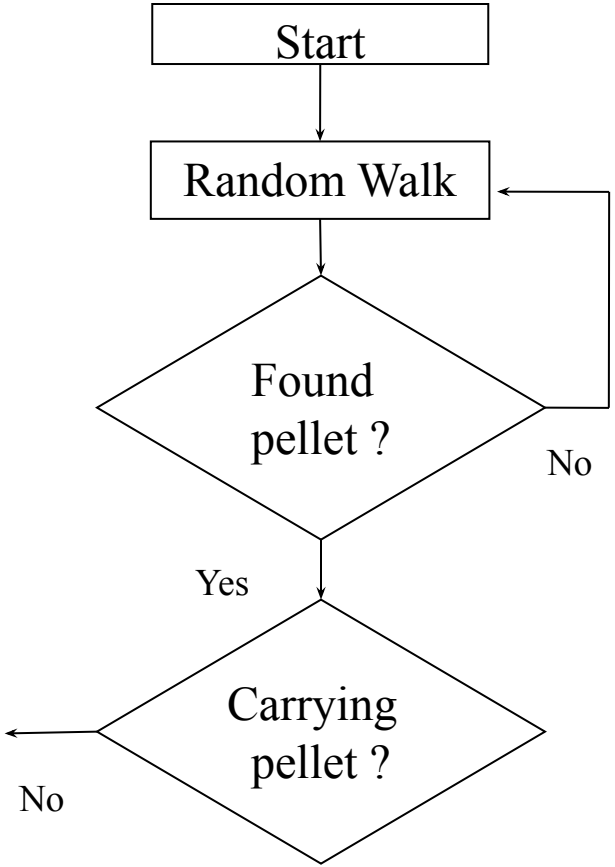

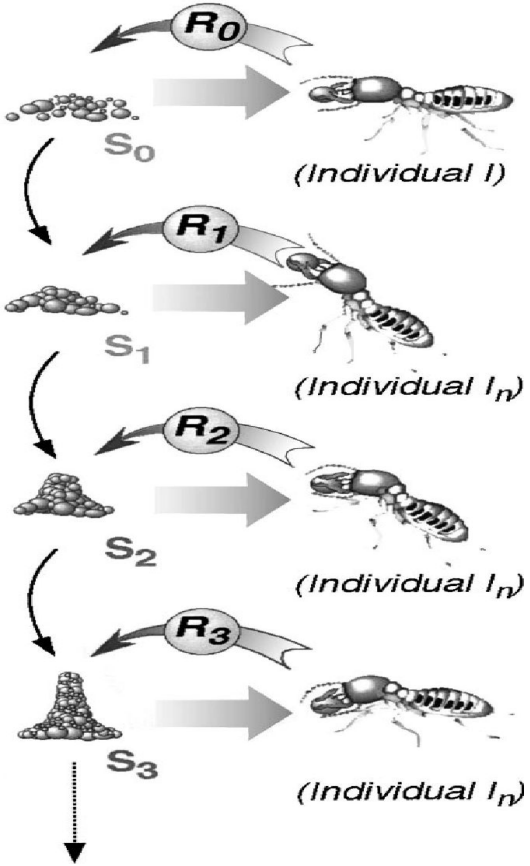

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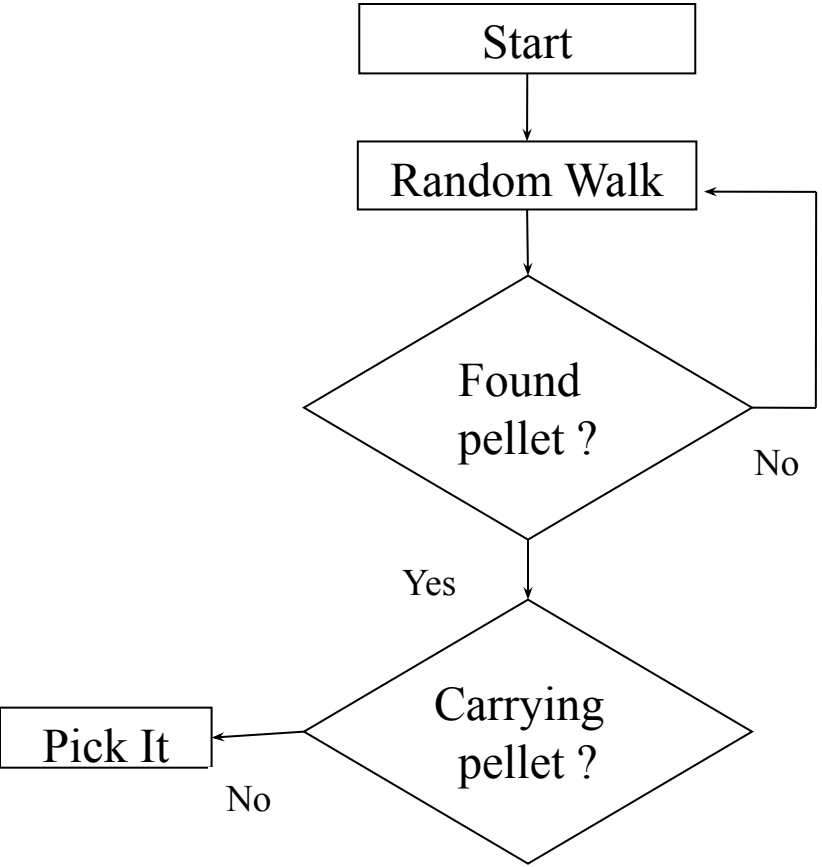

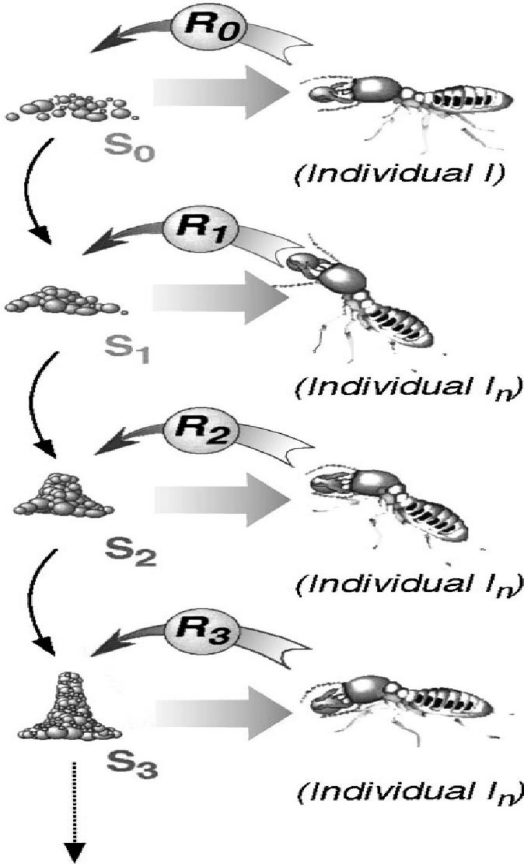

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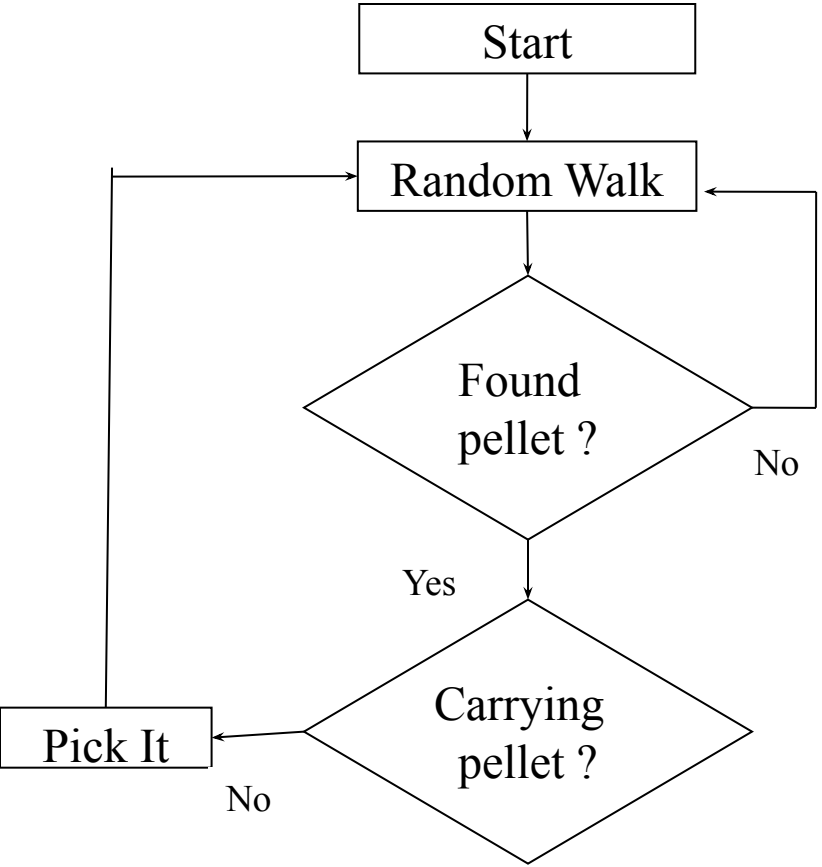

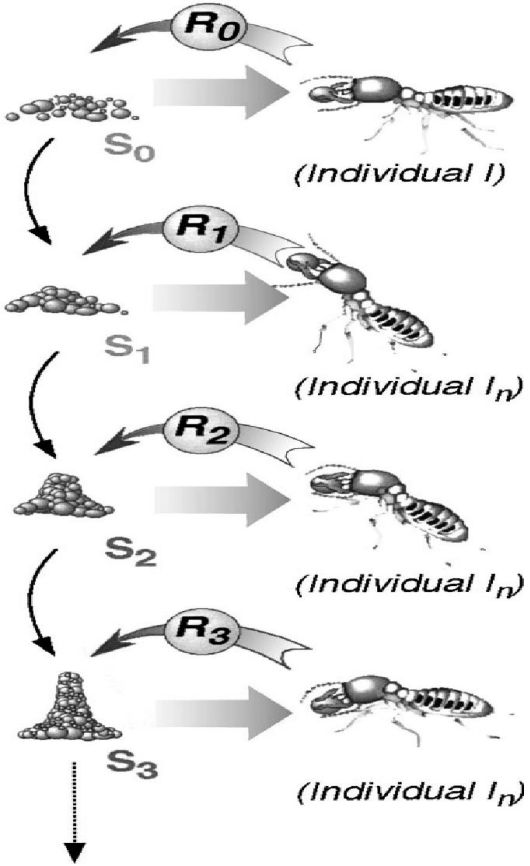

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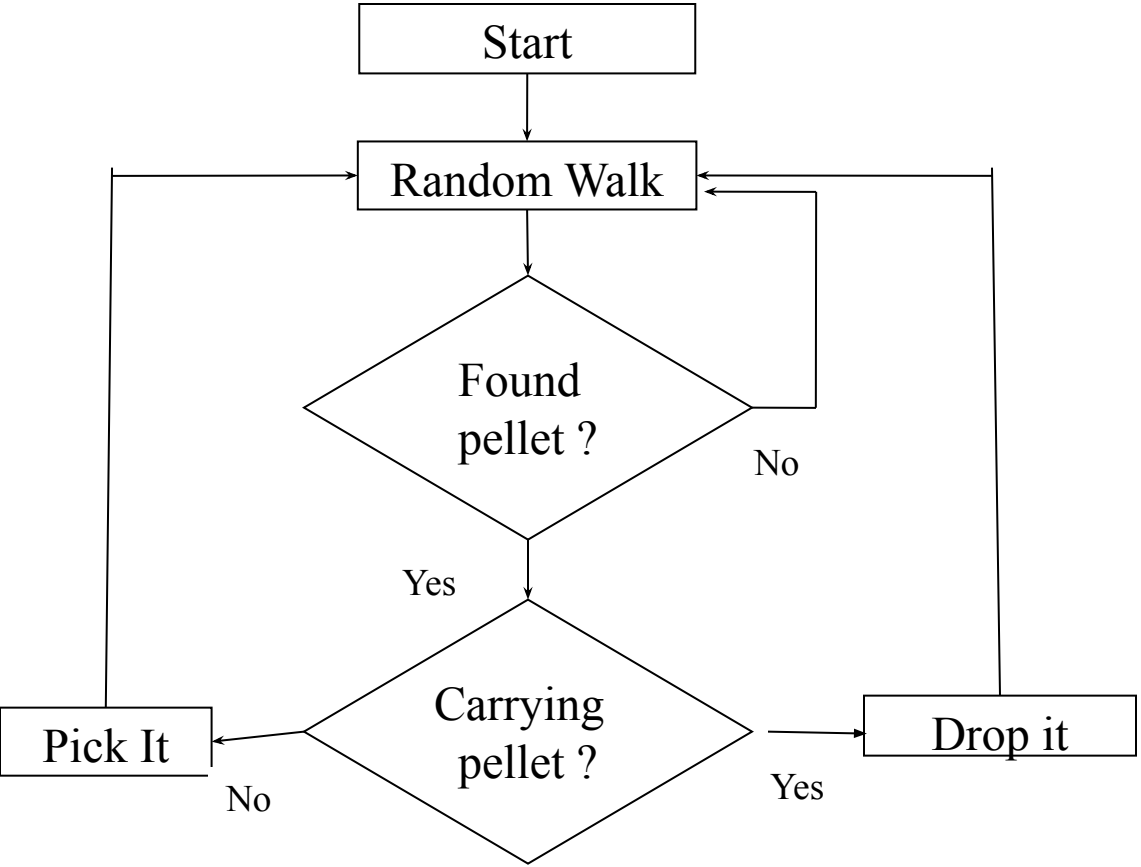
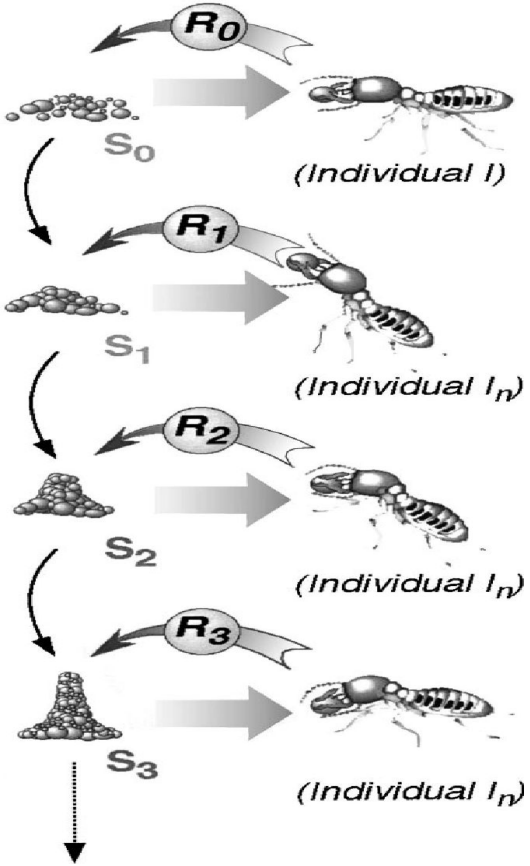


Flow Chart for Termite Worker



Hill Building Nature of Termite

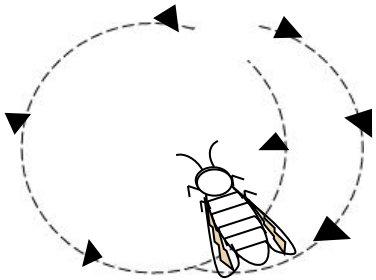
Analogy between the Termite Characteristics and Network Characteristics ?

Where Can I use this ?

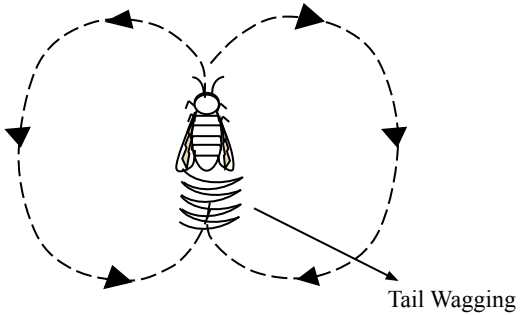
Bees

- Finding the nectar or pollen place.
- Recruiting the workers to collect the nectar or pollen
- Cannot use pheromone for communication
- Will use dancing language to communicate with the other workers in the hive
    - distance, direction and quality of the nectar and pollen

- Food source is within 50 meters from the hive, a worker bee performs round dance.

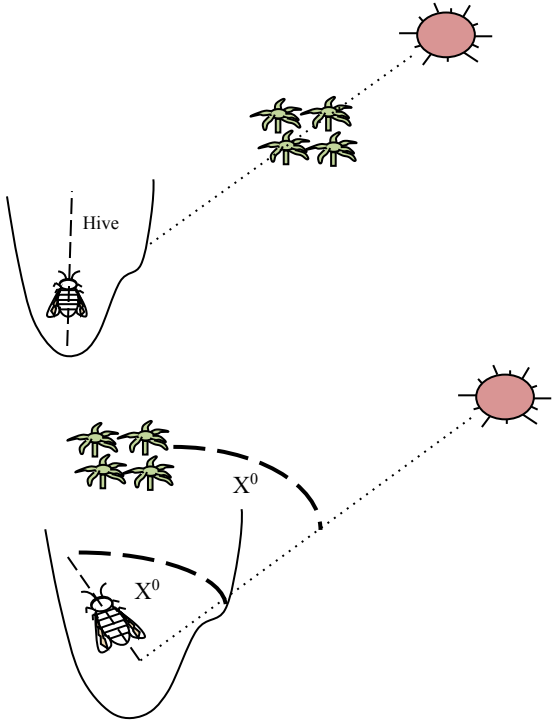


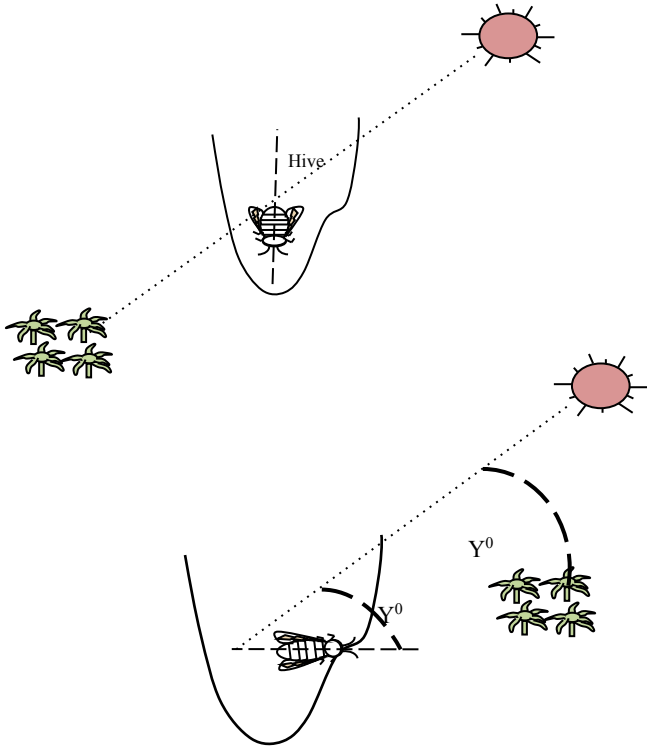
- If the food source is away from the hive for more than 50 meters, worker bee will perform *waggle dance or wag-tail dance*



- *duration of straight line, tempo of the dance, duration of the buzz sound* and *the dancing duration measured in seconds*

- Direction of the food source to the hive is bit convoluted
- If the food source is in the direction of the sun
  - Tail wagging dance vertically upward direction in the hive (Fig. 4a).
- If the food source is in the opposite direction of the sun
  - Tail wagging dance in vertically downward direction in the hive (Fig. 4b).
- If the food source is located at an angle *x* degrees to the left of sun,
  - Tail wagging dance at an angle *x* left of the vertical to the hive (Fig. 4c).
- If the food source is located at angle y degrees to the right of the sun,
  - The waggle dance at an angle *y* right of the vertical to the hive (Fig. 4d).


Hive
X0
X0


Hive
Y0
Y0

Analogy ?

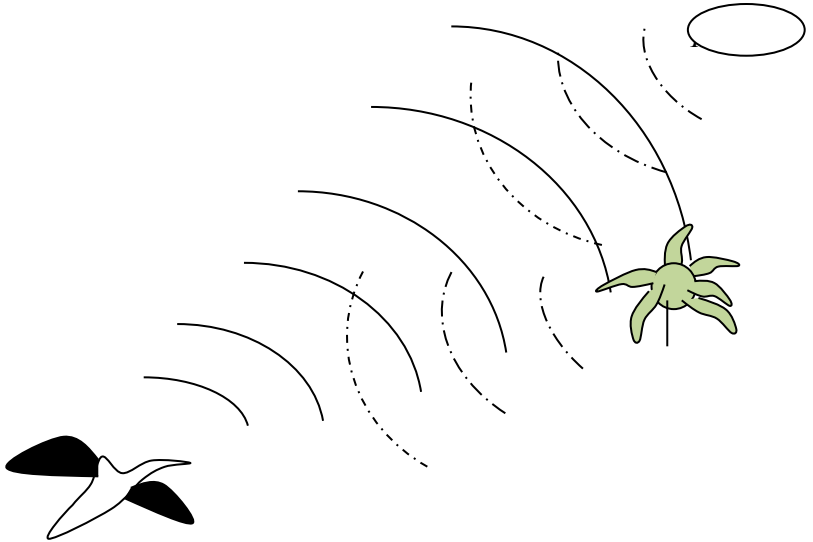
Scout Bee - checking the path resources

Bats

- Two distinct characteristics
  - only mammal to have wings
  - having advanced capability of echolocation
- The bats produce a very loud pulse and listen for the echo.
- The pulse varies when it echoes back.
- Type of prey, its distance, its orientation and its moving speed using the Doppler Effect.
- Eavesdrop the information to other specimens as well

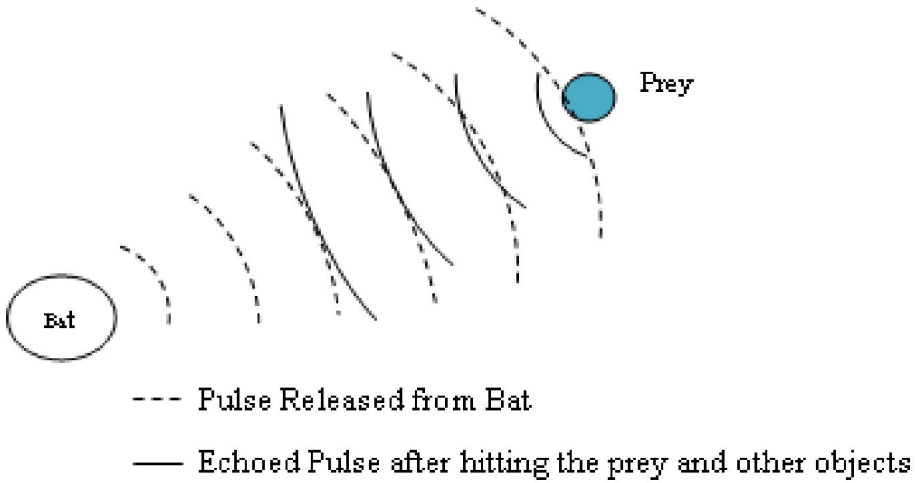
Echolocation in Bats

- These bats produce very loud pulse and listen for the echo.
- Allows them to find their prey and its other features in complete darkness.
- Find and differentiate different types of insects in complete darkness and locates and avoids obstacles on the fly.
- With this they can detect the distance and orientation of the target, type of prey and its moving speed using the Doppler Effect



Pulse Released from Bat

Echoed Pulse after Hitting the Prey and Other Objects


Prey
Bat
--- Pulse Released from Bat
—— Echoed Pulse after hitting the prey and other objects

Summary

- There are analogies in distributed computing and social insects
- Biology has found solution to hard computational problems
- Biologically inspired computing requires:
  - Identification of analogies
  - Computer modeling of biological mechanisms
  - Adaptation of biological mechanisms for IT applications

Future Directions…

- Literature explores intelligence of only single insects.
- Look around .. You may get a hint …