

### III Autonomous Agents & Self-Organization

9/15/04

1

### Autonomous Agent

- “a unit that interacts with its environment (which probably consists of other agents)
- but acts independently from all other agents in that it does not take commands from some seen or unseen leader,
- nor does an agent have some idea of a global plan that it should be following.”  
—Flake (p. 261)

9/15/04

2

### Nest Building by Termites (Natural and Artificial)

9/15/04

3

### Resnick’s Termites (“Turmites”)

9/15/04

4

### Basic procedure

- Wander randomly
- If you are not carrying anything and you bump into a wood chip, pick it up.
- If you are carrying a wood chip and you bump into another wood chip, put down the woodchip you are carrying

— Resnick, *Turtles, Termites, and Traffic Jams*

9/15/04

5

### Microbehavior of Termites

1. *Search for wood chip:*
  - a) If at chip, pick it up
  - b) otherwise wiggle, and go back to (a)
2. *Find a wood pile:*
  - a) If at chip, it's found
  - b) otherwise wiggle, and go back to (a)
3. *Find an empty spot and put chip down:*
  - a) If at empty spot, put chip down & jump away
  - b) otherwise, turn, take a step, and go to (a)

9/15/04

6

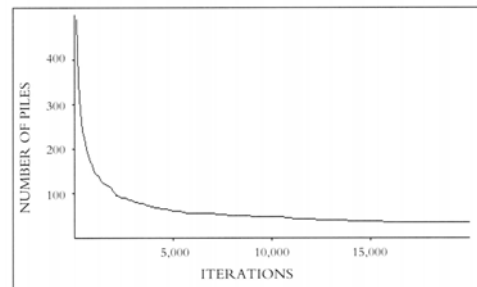
### Demonstration

[Run Termites.slogo](#)

9/15/04

7

### Decrease in Number of Piles



9/15/04

8

### Why does the number of piles decrease?

- A pile can grow or shrink
- But once the last chip is taken from a pile, it can never restart
- Is there any way the number of piles can increase?
- Yes, and existing pile can be broken into two

9/15/04

9

### More Termites

Termites	2000 steps		10 000 steps		
	num. piles	avg. size	num. piles	avg. size	chips in piles
1000	102	15	47	30	
4000	10		3	80	240

9/15/04

10

### Termite-Mediated Condensation

- Number of chips is conserved
- Chips do not move on own; movement is mediated by termites
- Chips preferentially condense into piles
- Increasing termites, increases number of chips in fluid (randomly moving) state
- Like temperature

9/15/04

11

### An Experiment to Make the Number Decrease More Quickly

- Problem: piles may grow or shrink
- Idea: protect “investment” in large piles
- Termites will not take chips from piles greater than a certain size
- Result: number decreases more quickly
- Most chips are in piles
- But *never* got less than 82 piles

9/15/04

12

### Conclusion

- In the long run, the “dumber” strategy is better
- Although it’s slower, it achieves a better result
- By not protecting large piles, there is a small probability of any pile evaporating
- So the smaller “large piles” can evaporate and contribute to the larger “large piles”
- Even though this strategy makes occasional backward steps, it outperforms the attempt to protect accomplishments

9/15/04

13

### Flake’s Version of Termites

[Run CBN Mac version of termites](#)

9/15/04

14

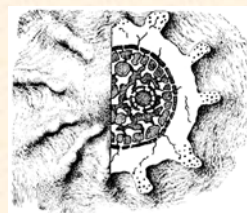
### Mound Building by *Macrotermes* Termites



9/15/04

15

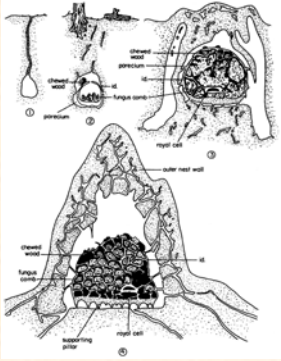
### Structure of Mound



9/15/04

figs. from Lüscher (1961)

16



**Construction of Mound**

- (1) First chamber made by royal couple
- (2, 3) Intermediate stages of development
- (4) Fully developed nest

9/15/04 Fig. from Wilson (1971) 17

The diagram illustrates the four stages of mound construction by ants. Stage 1 shows a small chamber made by the royal couple. Stages 2 and 3 show intermediate stages of development with increasing complexity and size. Stage 4 shows a fully developed nest with a large central chamber and a surrounding structure. Labels in the diagram include: 'chamber', 'passage', 'royal cell', 'queen', 'king', 'fungus chamber', 'chamber nest wall', 'chamber wall', 'fungus chamber', 'passage', 'royal cell', and 'supporting pillar'.