Dynamic Scheduling and Division of Labor in Social Insects

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The problem

- Each truck must be painted a different color
- Multiple booths exist that can paint one truck
- Each booth can paint one different color
- A booth can switch, but it costs time and money
- A booth can randomly break down for a time

Market based solution

- Booths follow four rules:
  - 1. Try to take another truck the same color as the current color.
  - 2. Take particularly important jobs.
  - 3. Take any job to stay busy.
  - 4. Do not take another job if paint booth is down or queue is full.

- Each booth is considered a separate agent and bids for each truck

- If no booths make a bid, then the truck is put in storage.

Ant based solution

- Similar to the market based solution, except the method used to determine the optimal booth is different

$$P_k = \frac{D_{c_i}^2}{D_{c_i}^2 + \alpha \cdot \theta_{k,c_i}^2 + \Delta T^{2 \cdot \beta}} \qquad P_{ij} = \frac{S_j^2}{S_j^2 + \alpha \theta_{i,j}^2 + \beta d_{z(i),j}^2}$$

$$\theta_{k,c_i} \leftarrow \theta_{k,c_i} - \xi \qquad\qquad \theta_{m,c_i} \leftarrow \theta_{m,c_i} + \phi$$

Genetic algorithm optimization

- The values *P, L, C* from the market solution, and the values α, β, ξ, φ, θ_{Min}, θ_{Max} need to be determined.

- Each value was determined by a genetic algorithm.
- For the first 50 generations the *Fitness* is defined as 1000 minus the number of time steps over 420 needed until the last truck is painted
- In the remainder of the generations the *Fitness* is this number minus the number of flushes needed by the booths during the 30 test runs

Results

	Test set 1							
	Market-Based				Ant-Based			
	Time		Flushes		Time		Flushes	
Booths	Avg.	Std. Dev.	Avg.	Std. Dev	Avg.	Std. Dev.	Avg.	Std. Dev
8	5.21	3.02	326.82	10.85	5.20	3.44	315.65	16.19
10	3.01	1.13	298.39	11.17	2.88	0.87	260.96	11.89
12	2.72	1.04	263.52	13.15	2.60	1.13	220.06	12.18
15	2.27	1.31	211.49	13.74	2.14	1.34	162.12	12.92

	Test set 2							
	Market-Based				Ant-Based			
	Time		Flushes		Time		Flushes	
Booths	Avg.	Std. Dev.	Avg.	Std. Dev	Avg.	Std. Dev.	Avg.	Std. Dev
6	5.94	6.80	122.94	16.13	6.82	7.86	114.46	21.95
7	1.82	2.13	95.72	12.87	2.24	1.76	77.52	12.36
8	1.19	1.95	79.15	11.29	1.81	1.58	61.94	9.53

Conclusions

- The ant based solution performed similarly to the market based solution based on time

- The ant solution performed much better on the amount of times needed to switch paint

- Both solutions performed better than a static scheduling system

Questions?