The Optimal Resource Allocation in Stochastic Activity Networks via The Electromagnetism Approach: a platform implementation in Java.

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Topics

1 – Problem Definition

2 – Research Lines

3 – Electromagnetism Approach

4 – Application Development

5 – Results

6 – Conclusions

7 - Future Research

1. Problem Definition (1/3)

- Given a multimodal activity network under stochastic conditions, we want to optimize the resource allocation to minimize cost

1. Problem Definition (1/3)

- Given a multimodal activity network under stochastic conditions, we want to optimize the resource allocation to minimize cost

1. Problem Definition (2/3)

- Work Content

  $W_a \sim \exp(\lambda_a)$

- Resource Allocation

  $l_a \leq x_a \leq u_a$

- Duration

  $Y_a = W_a / X_a$

- Resource Cost

  $RC_a = x_a W_a$

1. Problem Definition (3/3)

- Due date

  T

- Tardiness Cost

  $TC = c_L \max\{0, Y_n - T\}$

- One resource

- Goal: determine the resource allocation vector X, such that the total expected cost is minimized

2. Research Lines

- DP model
- Approximation still using DP, and NLP
- Electromagnetism Approach

3. Electromagnetism Approach (1/2)

Birbil and Fang

- Global Optimization Technique
- Developed to optimize functions with one or more variables
- Charge – based on the value of the objective function
- Forces of attraction and repulsion
- Direction of movement – vectorial sum

3. Electromagnetism Approach (2/2)

- Adaptation to the RCPSP

  (Particle: vector of resource allocations)

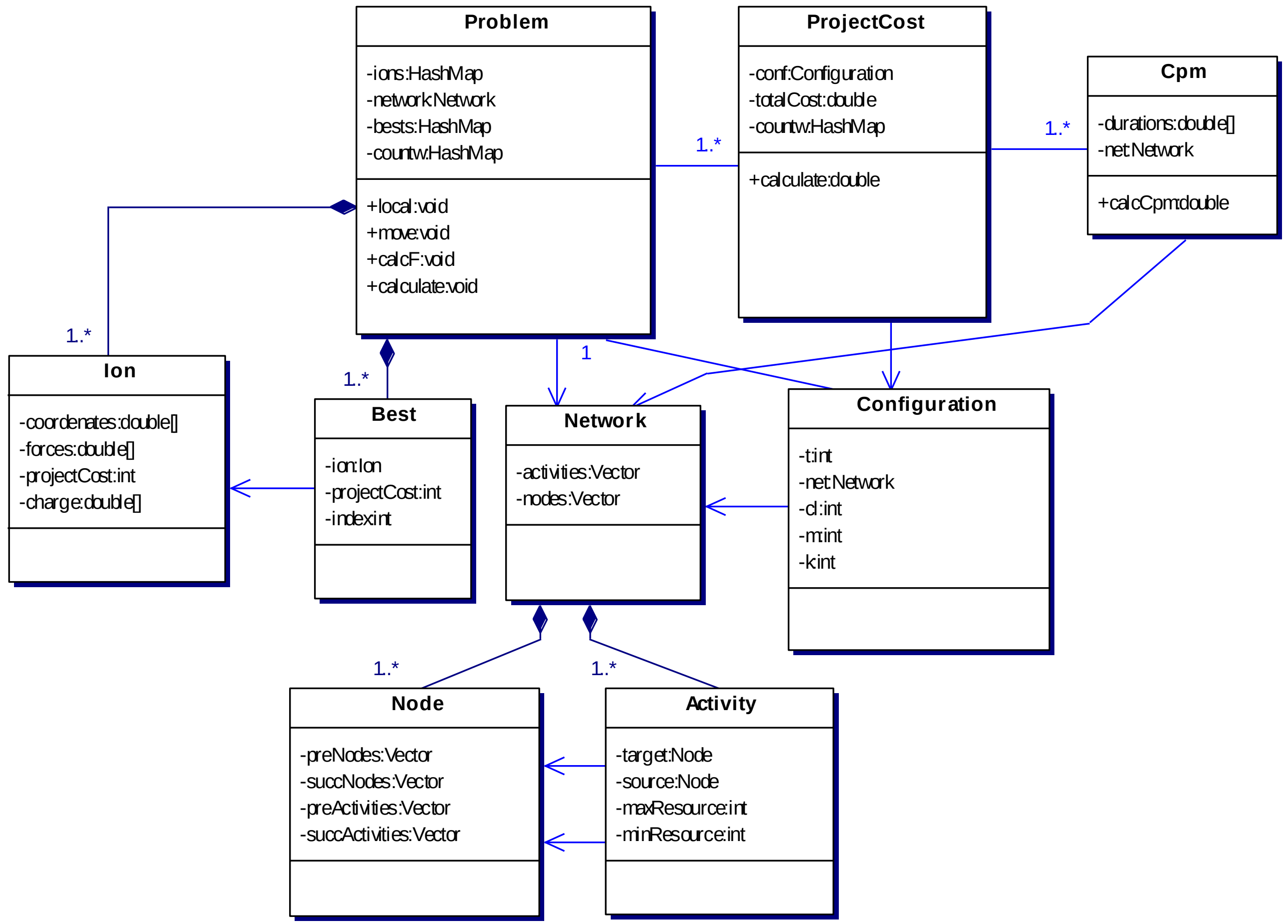
1. Generate k vectors of $W=(w_1..w_n)$ randomly
2. Generate m vectors of $X=(x_1..x_n)$ to start with
3. For each vector X
4. For each vector W
5. $rc=\sum x_a W_a$; $tc = c_L \max\{0, Y_n-T\}$; $c=rc+tc$
6. $f = \sum c / k$; Charges; Forces
7. Move the points
8. Go to step 3 until nº of iterations specified is reached

4. Application Development (1/3)

- Programming language: Java
- Main classes created:
  - Node
  - Activity
  - Network
  - Ion
  - ProjectCost
  - Problem
  - Configuration

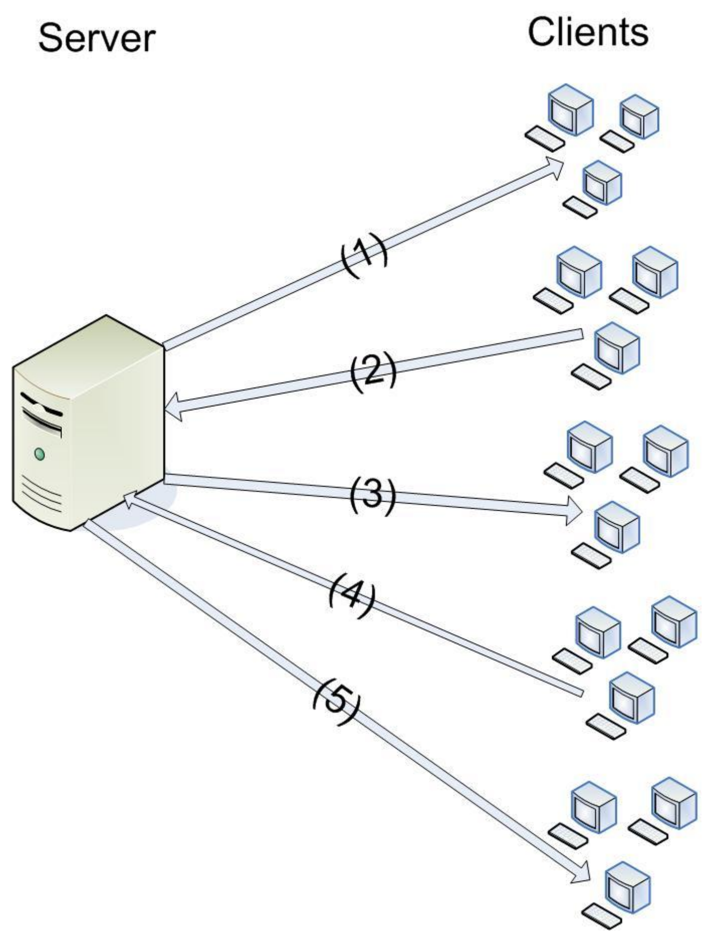
4. Application Development (2/3)

Class Diagram



4. Application Development (3/3)

Distributed implementation of EMA



5. Results (1/6)

Experiment Layout

Network	Number of activities	T	c_L
1	3	16	2
2	5	120	8
3	7	66	5
4	9	105	4
5	11	28	8
6	11	65	5
7	12	47	4
8	14	37	3
9	14	188	6
10	17	49	7
11	18	110	10
12	24	223	12
13	38	151	5
14	49	155	5

5. Results (2/6)

Single Mode Results (k=10)

	n	T	c_L	EMA (Java)			DPM (Java)		
				C	RunT	N.Ev	C	RunT	K1
Net1	3	16	2	23	0.23s	1125	44	0.02s	5
Net2	5	120	8	166	0.42s	1875	305	0.14s	5
Net3	7	66	5	66	0.84s	2625	194	0.19s	5
Net4	9	105	4	290	1.77s	3375	400	5.22s	5
Net5	11	28	8	66	3.02s	4125	130	22.42s	5
Net6	11	65	5	263	4.06s	4125	272	2m 33s	5
Net7	12	47	4	166	5.13s	4500	183	19m 13s	5
Net8	14	37	3	98	7.30s	5250	120	1h 36m 17s	5
Net9	14	188	6	202	10.31s	5250	1276	18h 16m 23s	5
Net10	17	49	7	54	18.94s	6375	141	4h 52m 23s	5
Net11	18	110	10	182	32.78s	6750	358	218h 50m	5
Net12	24	96	16	639	1m 03s	7875	*	*	*
Net13	38	151	5	771	1m 47s	9000	*	*	*

* Network too big for DPM.

5. Results (3/6)

Single Mode Results (k=100)

	n	T	c_L	EMA (Java)			DPM (Java)		
				C	RunT	N.Ev	C	RunT	K1
Net1	3	16	2	37	0.66s	1125	44	0.02s	5
Net2	5	120	8	321	2.16s	1875	305	0.14s	5
Net3	7	66	5	175	6.14s	2625	194	0.19s	5
Net4	9	105	4	312	14.61s	3375	400	5.22s	5
Net5	11	28	8	122	26.94s	4125	130	22.42s	5
Net6	11	65	5	253	31.57s	4125	272	2m 33s	5
Net7	12	47	4	160	47.77s	4500	183	19m 13s	5
Net8	14	37	3	120	1m 07s	5250	120	1h 36m 17s	5
Net9	14	188	6	810	1m 40s	5250	1276	18h 16m 23s	5
Net10	17	49	7	161	3m 05s	6375	141	4h 52m 23s	5
Net11	18	110	10	386	5m 22s	6750	358	218h 50m	5
Net12	24	96	16	622	10m 25s	7875	*	*	*
Net13	38	151	5	1580	17m 05s	9000	*	*	*

* Network too big for DPM.

5. Results (4/6)

Matlab versus Java

	Matlab (EMA)	Java (EMA)
Net1	14.0s	0.7s
Net2	32.4s	2.2s
Net3	1m 6s	6.2s
Net4	1m 48s	14.6s
Net5	2m 18s	27.0s
Net6	2m 42s	32.0s
Net7	3m 30s	47.8s
Net8	4m 12s	1m 07s
Net9	5m 01s	1m 40s
Net10	7m 30s	3m 05s
Net11	9m 42s	5m 22s
Net12	18m 30s	10m 25s
Net13	60 m	17m 05s

5. Results (5/6)

Distributed Mode Results

	n	T	c_L	SM			DM		
				k=300	k=600	k=1200	k=300	k=600	k=1200
Net1	3	16	2	2.81s	5.36s	11.44s	3m 27s	3m 02s	2m 45s
Net2	5	120	8	11.70s	23.03s	46.47s	4m 21s	4m 21s	4m 27s
Net3	7	66	5	33.45s	1m 08s	2m 16s	5m 26s	5m 03s	5m 35s
Net4	9	105	4	1m 24s	2m 47s	5m 31s	6m 9s	5m 35s	6m 56s
Net5	11	28	8	2m 35s	5m 04s	10m 17s	7m 01s	7m 55s	7m 55s
Net6	11	65	5	3m 02s	6m 02s	11m 59s	7m 03s	8m 09s	7m 29s
Net7	12	47	4	4m 29s	8m 56s	18m 15s	8m 15s	8m 14s	7m 24s
Net8	14	37	3	6m 28s	12m 49s	25m 51s	9m 23s	9m 17 s	8m 45s
Net9	14	188	6	9m 13s	18m 25s	37m 24s	9m 51s	9m 42s	9m 54s
Net10	17	49	7	17m 44s	35m 03s	1h 10m 24s	10m 26s	11m 10s	11m 53s
Net11	18	110	10	29m 59s	1h 23s	2h 1m 15s	11m 54s	11m 59s	12m 05s
Net12	24	96	16	58m 50s	1h 57m 05s	3h 58m 3s	13m 32s	13m 34s	17m 07s
Net13	38	151	5	1h 39m 27	3h 18m 24s	6h 37m 58s	15m 21s	15m 23s	19m 41s
Net14	49	151	5	24h 30m **	38h 30m **	38h 30m **	1h 01m	1h 16m 59s	2h 06m

** Test not finished

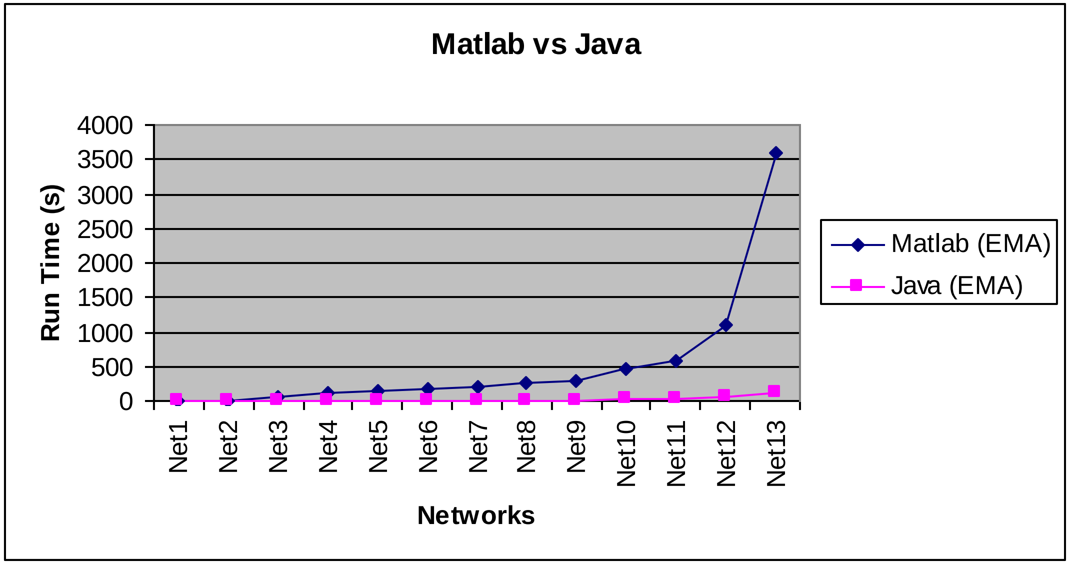
5. Results (6/6)

Distributed Mode Results

	n	T	c_L	k	SM	c=2 DM	c=4 DM	c=6 DM
Net1	3	16	2	600	5.36s	2m 45s	2m 38s	3m 02s
Net2	5	120	8	600	23.30s	3m 28s	3m 58s	4m 21s
Net3	7	66	5	600	1m 08s	4m 29s	4m 50s	5m 03s
Net4	9	105	4	600	2m 47s	6m 46s	6m 11s	5m 35s
Net5	11	28	8	600	5m 04s	8m 02s	7m 09s	7m 55s
Net6	11	65	5	600	6m 02s	7m 45s	6m 47s	8m 09s
Net7	12	47	4	600	8m 56s	8m 12s	8m 33s	8m 14s
Net8	14	37	3	600	12m 49s	9m 48s	9m 01s	9m 17s
Net9	14	188	6	600	18m 25s	9m 38s	9m 28s	9m 42s
Net10	17	49	7	600	35m 03s	11m 04s	11m 16s	11m 10s
Net11	18	110	10	600	1h 23s	14m 27s	11m 40s	11m 59s
Net12	24	96	16	600	1h 57m 05s	16m 53s	13m 33s	13m 34s
Net13	38	151	5	600	3h 18m 24s	19m 24s	18m 06s	15m 23s
Net14	49	151	5	600	38h 30m *	2h 30m	1h 45m	1h 16m 59s

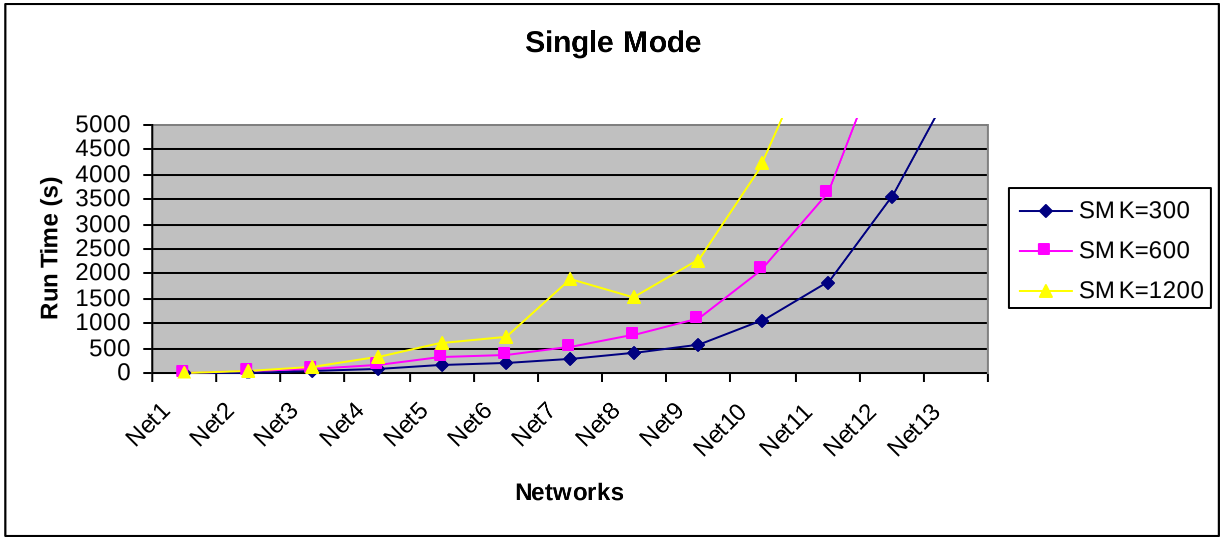
6. Conclusions (1/4)

- EMA faster then DPM for large networks
- Running times differences



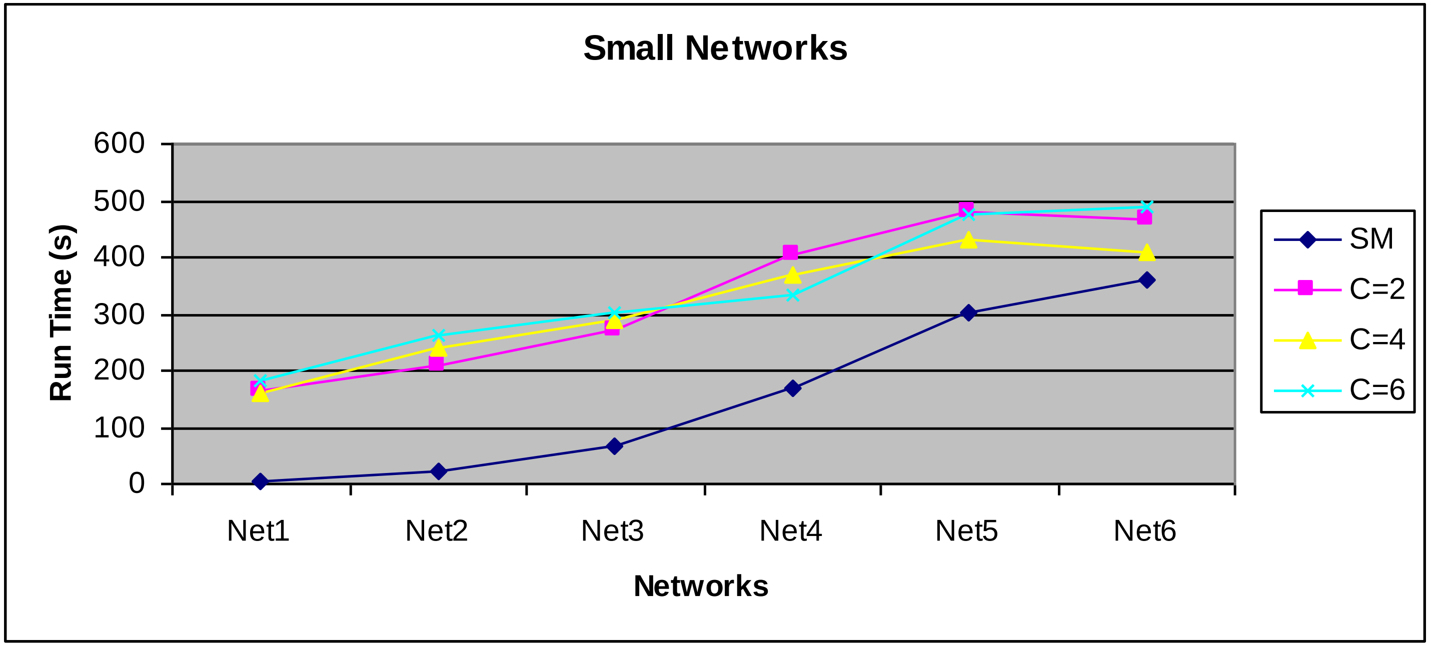
6. Conclusions (2/4)

- Running time increases as K increases



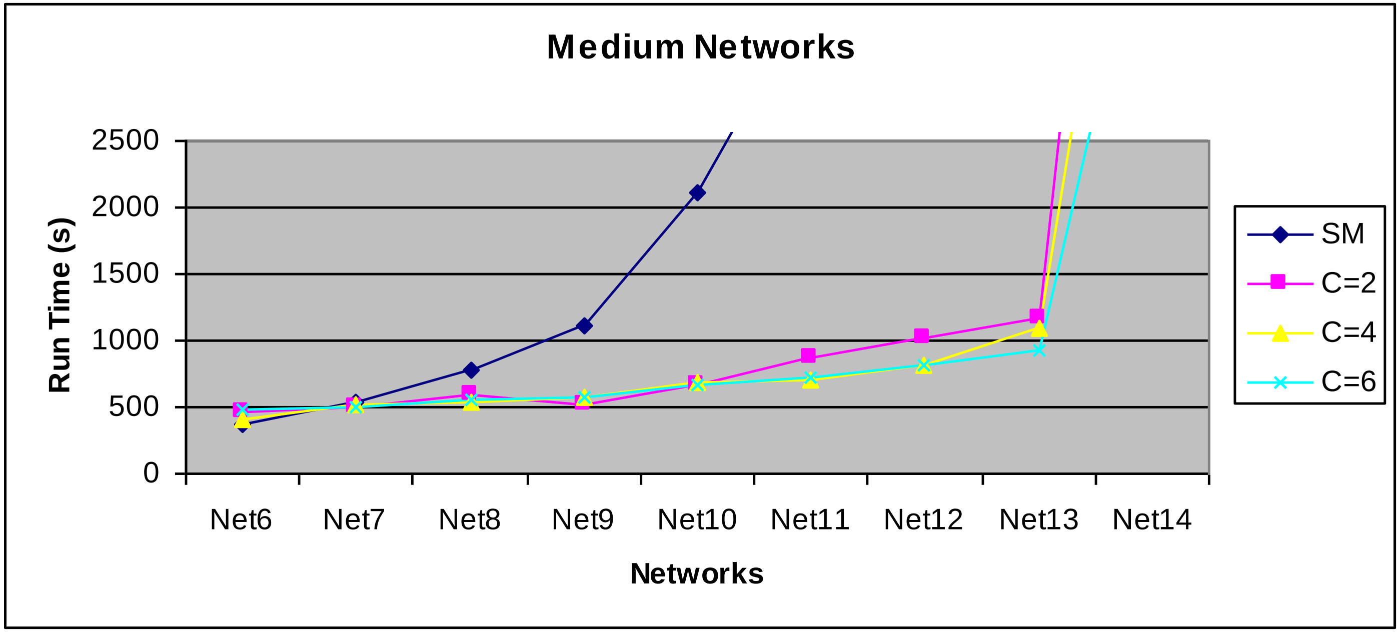
6. Conclusions (3/4)

- Single Mode vs. Distributed Mode



6. Conclusions (4/4)

- Single Mode vs. Distributed Mode



7. Future research

- Evolutionary Algorithms
- Use other probability distributions
- Extend the problem to have more than one resource
- Inject the concept of “Intentional Delays” into the problem
  – Use discount factors
  – What is the optimal delay on each activity
  – Minimize the present value of the project

Major References

1. Birbil, S. I. and Fang, S-C. (2003) An Electromagnetism-Like Mechanism for global optimization. Journal of Global Optimization, 25, 263-282.

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