

The Optimal Resource Allocation in Stochastic Activity Networks via The Electromagnetism Approach

Anabela P. Tereso (UM - Portugal)

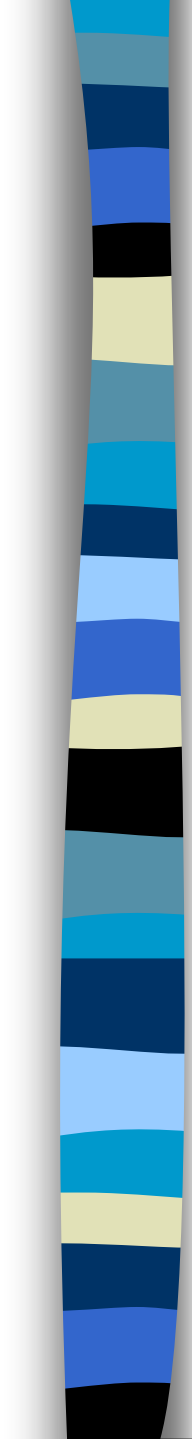
anabelat@dps.uminho.pt

M. Madalena T. Araújo (UM - Portugal)

mmaraujo@dps.uminho.pt

Salah E. Elmaghraby (NCSU - USA)

elmaghra@eos.ncsu.edu



Topics

1 – Problem Definition

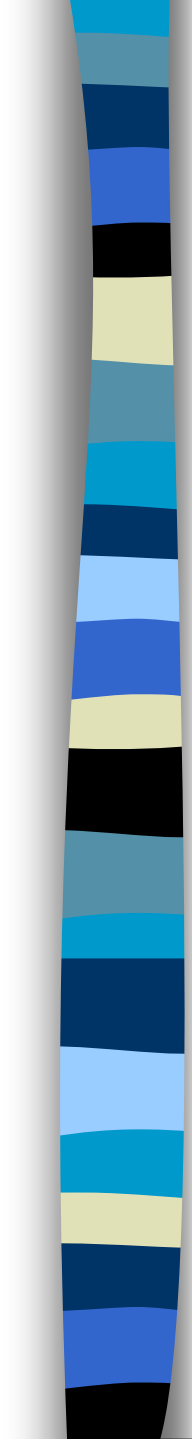
2 – Research Lines

3 – Electromagnetism Approach

4 – Computational Results

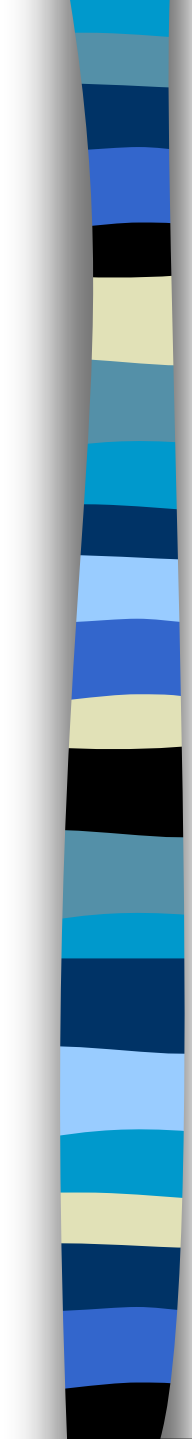
5 – Conclusions

6 - Future Research



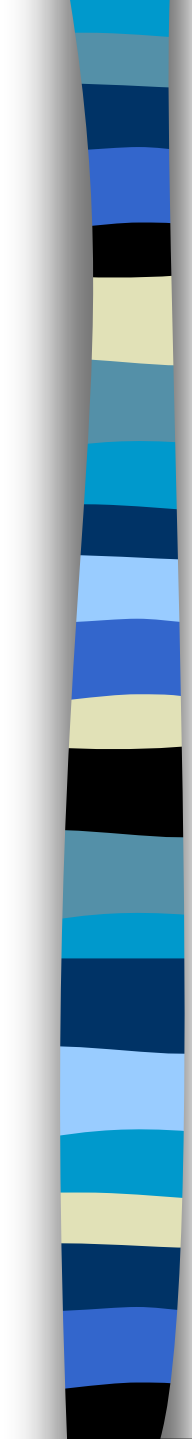
1. Problem Definition ^(1/3)

- 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

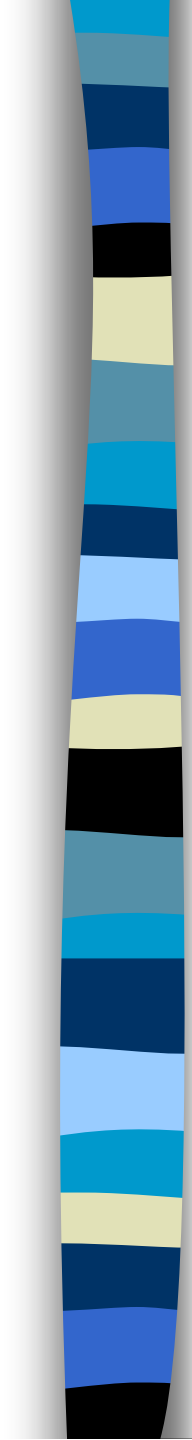
$$l_a \leq x_a \leq u_a$$

- Duration

$$Y_a = W_a / X_a$$

- Resource Cost

$$RC_a = x_a W_a$$



1. Problem Definition (3/3)

- Due date

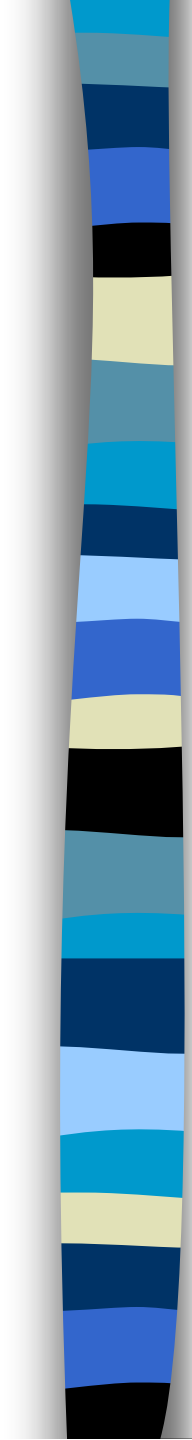
T

- Tardiness Cost

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

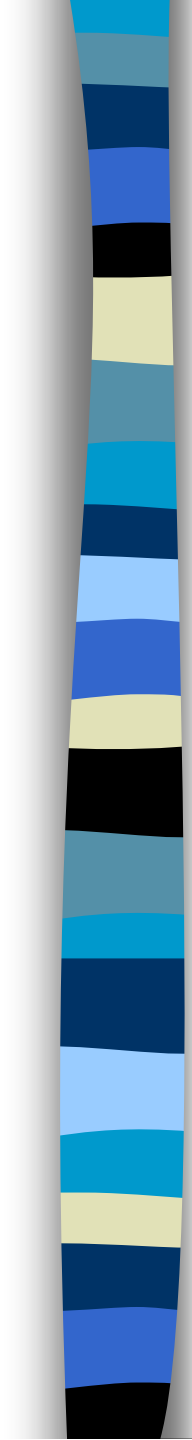
- One resource

- 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 – value of the objective function
- Forces of attraction and repulsion
- Direction of movement – vectorial sum

3. Electromagnetism Approach (2/2)

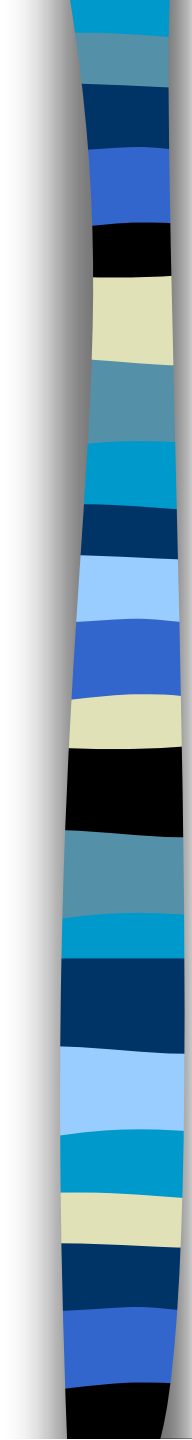
■ Adaptation to the RCPSP

(Particle: vector of resource allocations)

1. Generate k vectors of $X=(x_1..x_n)$ to start with
2. For each vector X
3. Generate m vectors of $W=(w_1..w_n)$ randomly
4. For each vector W
5. $rc=\sum x_a W_a$; $tc = c_L \max \{0, Y_n - T\}$; $f=rc+tc$
6. Charge of each point = $\sum f / m$; Forces
7. Move the points
8. Go to step 2 until n^0 of iterations specified is reached

4. Computational Results

Net	n	PERT	T	c_L	DP Points	DP Best Cost	DP Time	EMA Best Cost	EMA Time
1	3	15	16	2	3	43.32	0.06 sec	39.58	2.05 min
2	5	115	120	8	3	304.62	0.98 sec	330.97	3.88 min
3	7	62.9	66	5	3	209.94	3.03 sec	168.02	6.18 min
4	9	100	105	4	3	387.20	1.14 min	320.16	8.87 min
5	11	26.67	28	8	3	106.76	7.43 min	118.78	11.67 min
6	11	62.08	65	5	3	208.85	45.49 min	238.84	11.94 min
7	12	44.72	47	4	3	182.91	5.77 hr	132.12	13.99 min
8	14	35.5	37	3	2	116.49	31.89 min	91.80	17.12 min
9	14	178.57	188	6	2	645.39	6.45 hr	609.55	17.90 min
10	17	44.98	49	7	2	160.12	4.17 hr	105.88	24.56 min
11	18	106.11	110	10	2	339.07	30.18 hr	333.63	28.55 min
12	24	212.05	223	12	2	-	>48hr	857.70	47.19 min
13	38	143.99	151	5	2	-	>48 hr	693.07	1.98 hr
14	76	115.01	121	4	2	-	>48 hr	475.14	8.88 hr



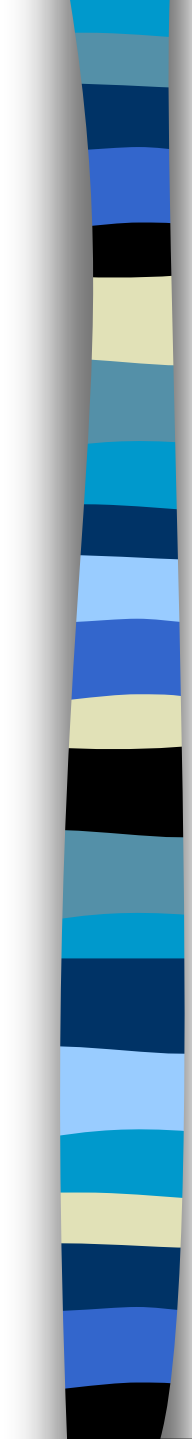
5. Conclusions

■ Strait DP model

- More time consuming when applied to the bigger networks
- Theoretically: an optimization model
- Due to discretizations: upper limit to the optimum

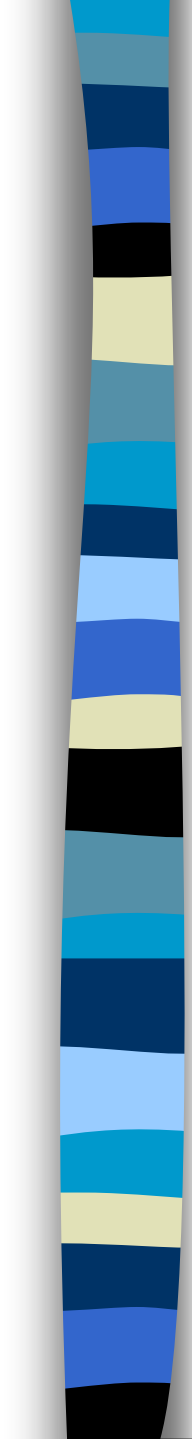
■ EM Algorithm

- Decreases running time for bigger networks
- Cost value seems closer to the optimum
- Theoretically: an optimization model



6. Future research

- Improvement of the performance of the EMA
- Modify the problem
 - Limited total availability of resources
 - Limited/Random total availability of resources
 - More than one resource for each activity



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.
2. TERESO, A.P.; ARAÚJO, M.M. and ELMAGHRABY, S.E. (2001): Adaptive Resource Allocation in Multimodal Activity Networks. Research Report, Universidade do Minho, Guimarães, Portugal. Accepted for publication in the *International Journal of Production Economics*.
3. TERESO, A.P.; ARAÚJO, M.M. and ELMAGHRABY, S.E. (2003a): Experimental Results of an Adaptive Resource Allocation Technique to Stochastic Multimodal Projects. Research Report, Universidade do Minho, Guimarães, Portugal. Submitted for publication.
4. TERESO, A.P.; ARAÚJO, M.M. and ELMAGHRABY, S.E. (2003b): Basic Approximations to an Adaptive Resource Allocation Technique to Stochastic Multimodal Projects. Research Report, Universidade do Minho, Guimarães, Portugal. Submitted for publication.