Integrated scheduling of maintenance and transportation operations in military supply chains

Eugene Levner

Ashkelon Academic College, Israel

Frank Werner

[2]Otto-von-Guericke-Universität, Magdeburg, Germany

(this work was done with **Dmitry Tsadikovich** and **Hanan Tell** (BIU))

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Outline

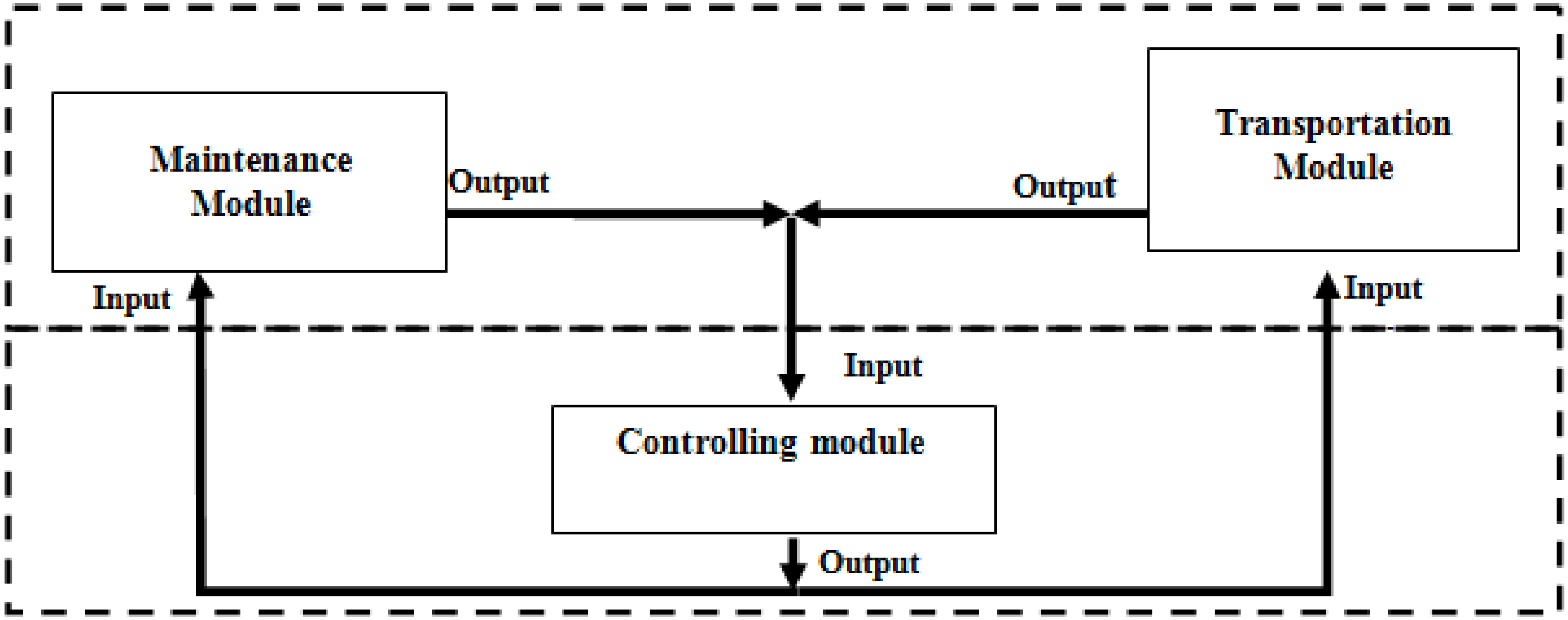
This talk will be around the following issues:

- Modeling the maintenance module (MM) and transportation module (TM) in MSC
- Design of the iterative local-search procedure proved to be more efficient than the standard GAMS/CPLEX solver

A military supply chain has the following linked activities:

- procurement,
- production,
- packaging,
- warehousing,
- repair,
- **maintenance** and
- **transportation** of army supplies.

Interaction between the modules



Model MM

To find $Min \sum_{j=1}^{n} F_j$ (1)

subject to:

$Y_{i'j} - Y_{ij} \geq p_{ij} - U_{ij}$, for all $(i,j) \rightarrow (i',j) \in A$ (2)

$Y_{ij} - Y_{ij'} \geq p_{ij'} - U_{ij'}$ or $Y_{ij'} - Y_{ij} \geq p_{ij}$, for all (i,j') and (i,j), $i = 1,2,\ldots,m$, $j = 1,2,\ldots,n$ (3)

$\sum_{i \in L_{j,k(j)}} B_{ij,k(j)} = 1$, for all $L = \{L_{j,k(j)}\}$, $j = 1,2,\ldots,n$, $k(j) = 1,2,\ldots,K_j$ (4)

$F_j \leq D_j$, for all $j = 1,2,\ldots,n$ (5)

$Y_{ij} \geq 0$, for all $(i,j) \in N$ (6)

$B_{ij,k(j)} \in \{0,1\}$, for all $i = 1,2,\ldots,m$, $j = 1,2,\ldots,n$, $k(j) = 1,2,\ldots,K_j$ (7)

Model TM

To find $Min \ \frac{-}{S} \sum_{(a,b)\in E} (t_{ab} - W_{ab}) x_{ab}$ (8)

subject to:

$$\sum_{b\in\Re} x_{0b} = S \qquad (9)$$

$$\sum_{a\in\Re} x_{a0} = \sum_{b\in\Re} x_{0b} \qquad (10)$$

$$\sum_{b\in\Re} x_{ab} = 1, \forall a \in \Re \qquad (11)$$

$$\sum_{b\in\Re} x_{ba} = 1, \forall a \in \Re \qquad (12)$$

$$z_{ab} \le x_{ab}, \forall (a,b) \in E \qquad (13)$$

$$\sum_{(a,b)\in E} z_{ab} \le S_{con} \qquad (14)$$

$$s_a + t_a^u + (t_{ab} - W_{ab}) - \Delta t_{ab} z_{ab} - s_b \le M * (1 - x_{ab}), \quad \forall (a,b) \in I \cup (\{0\} \times \Re) \qquad (15)$$

$$u_a \le s_a + t_a^u \le r_a, \forall a \in \Re \qquad (16)$$

$$0 \le y_a \le C, \forall a \in \Re \qquad (17)$$

$$y_a + q_a - y_b \le M * (1 - x_{ab}), \forall (i,j) \in I \cup (\{0\} \times \Re) \qquad (18)$$

$$s_a, y_a \ge 0, \forall a \in \Re \qquad (19)$$

Model CM

Problem CM.

To find $Min\ P = F_{TR}(W_{ab}) - F_{MM}(U_{ij})$ (21)

where

$$F_{TR}(W_{ab}) = \sum_{(a,b)\in E}(t_{ab} - W_{ab}) + \sum_{a\in\Re} t_a^u \text{, and } F_{MM}(U_{ij}) = \sum_{i=1}^{m}\sum_{j=1}^{n}(Y_{ij} + p_{ij} - U_{ij}) \text{.} \quad (22)$$

subject to:

$$\sum_{(a,b)\in E} W_{ab} \le \alpha_1 \quad (23)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} U_{ij} \le \alpha_2 \quad (24)$$

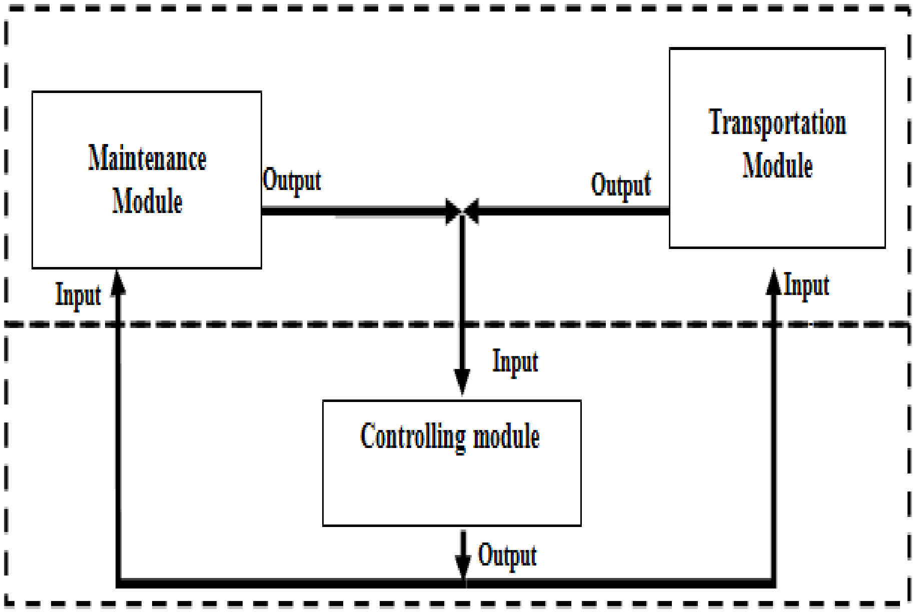
$$W_{ab} \ge s_b - r_b \quad (25)$$

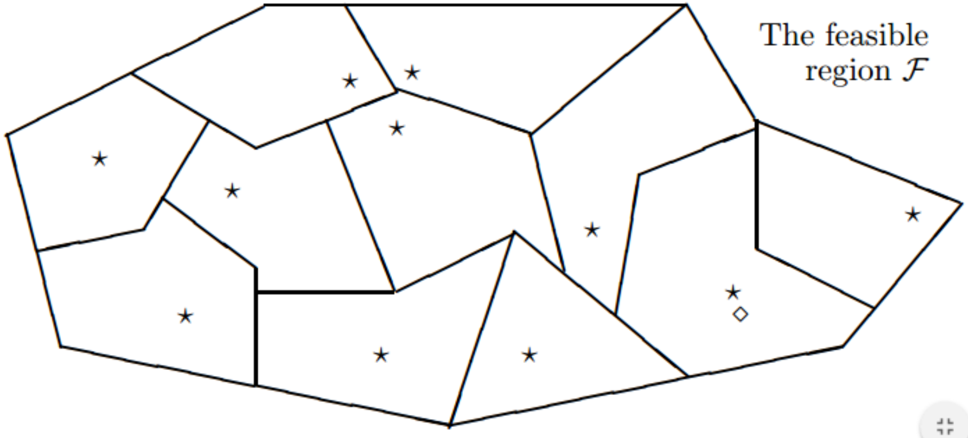
$$\sum_{j=1}^{n} Q_{jk}^a \le C \text{, for } k = 1,\dots,S \text{, } a = 1,\dots,\Re \quad (26)$$

$$\sum_{k=1}^{S} Q_{jk}^a = TQ_j^a \text{, for } j = 1,\dots,n \text{, } a = 1,\dots,\Re \quad (27)$$

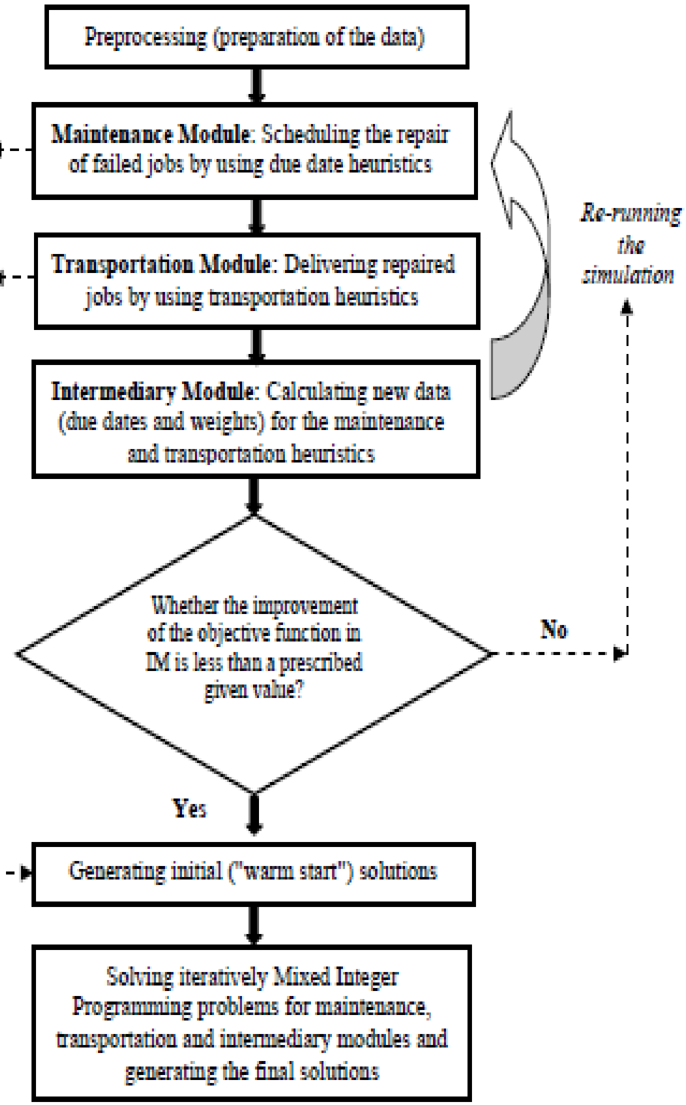
$$t_a^u = \beta\sum_{k=1}^{S}\sum_{j=1}^{n} Q_{jk}^a \text{, for } a = 1,\dots,\Re \quad (28)$$

Idea of Decomposition and Control

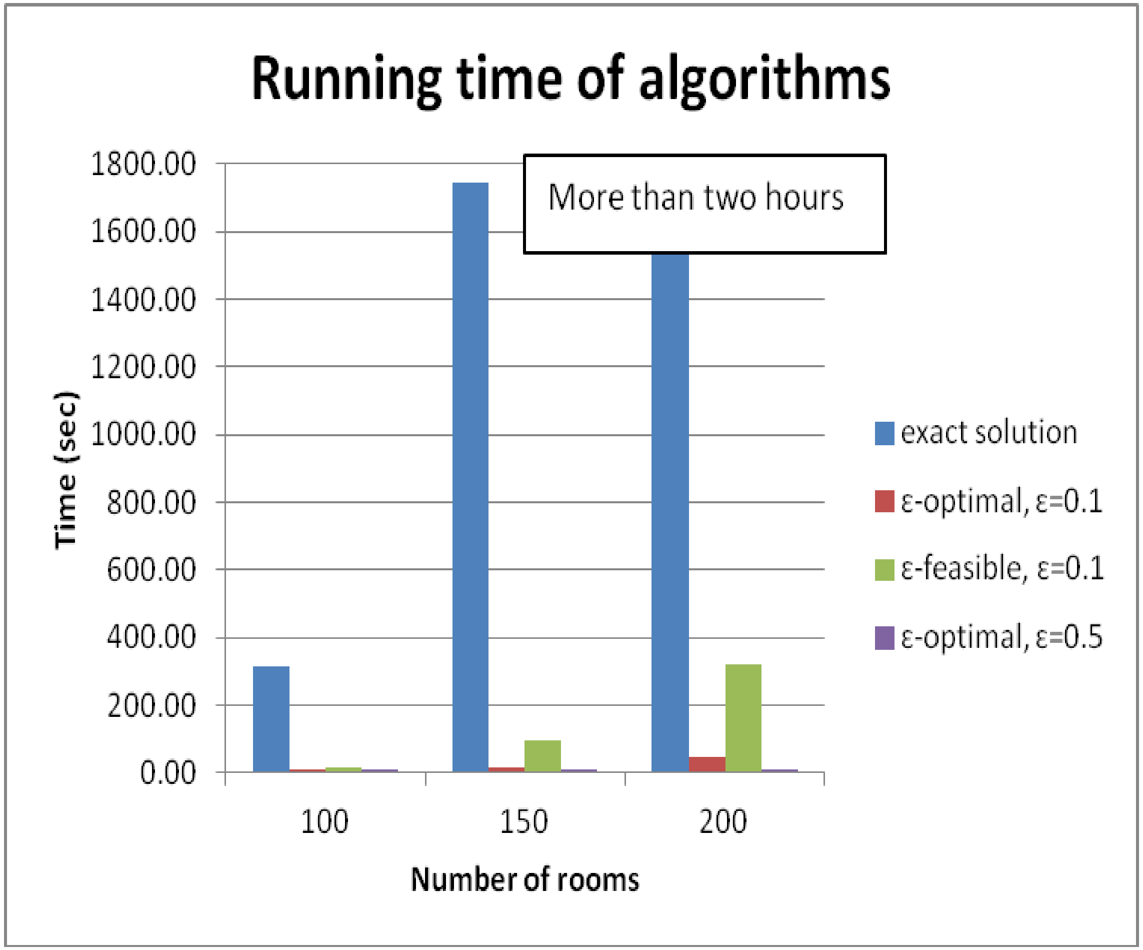




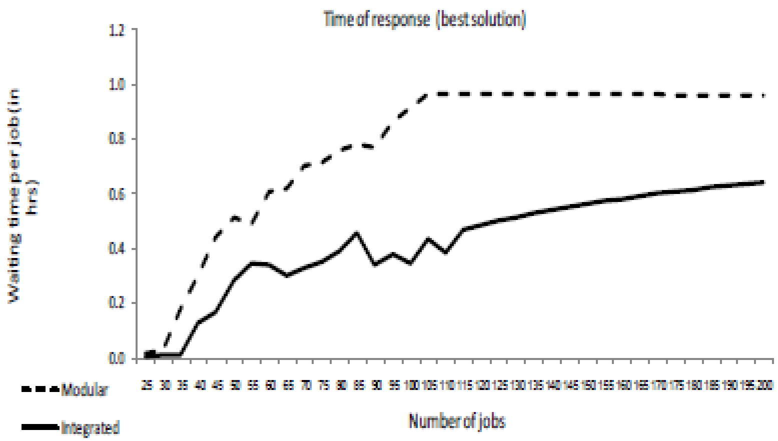
Flowchart of the algorithm

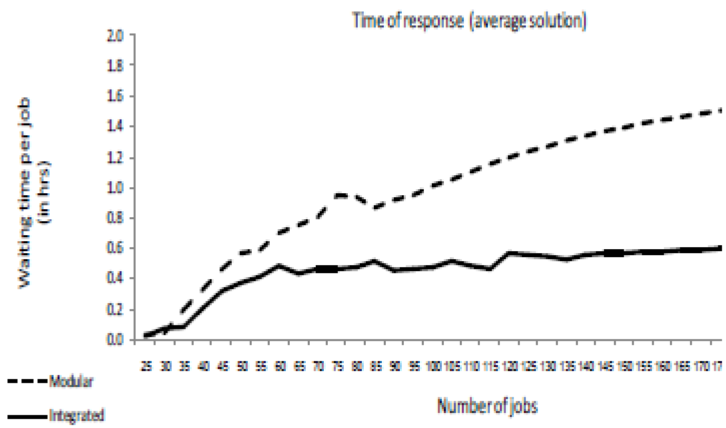


Computational results: Computing time



Computational results: Time of response





Computational results: Military effectiveness

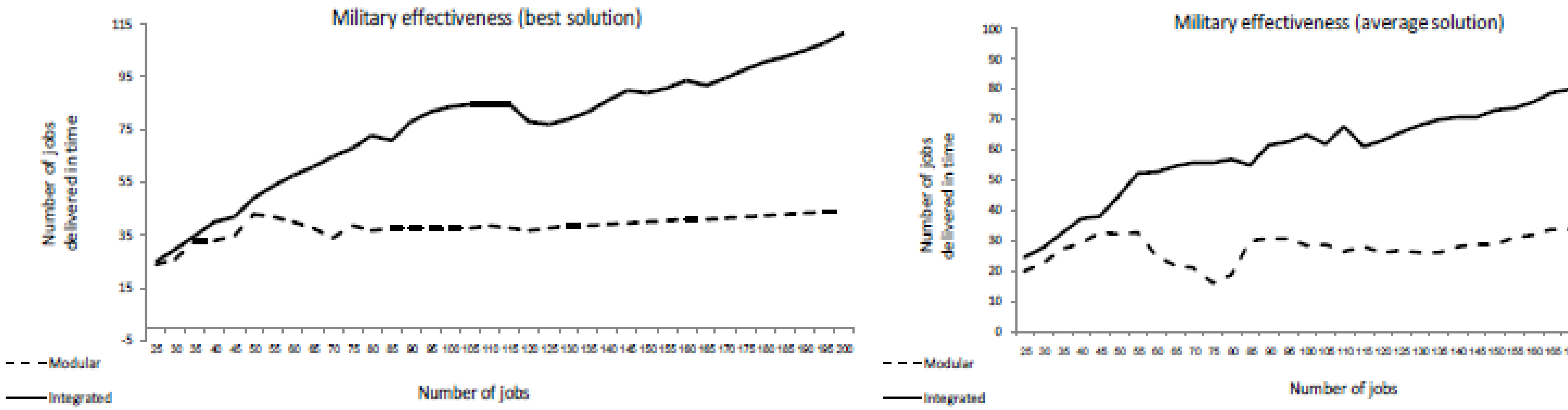


Fig. 5. The military effectiveness measure as a function of the number of jobs.

Conclusion

- A new general framework for improving the computational process of coordinating MSC is applicable for many other SCM problems.
- Further development of new, highly-efficient decomposition methods is possible for other types of problems like lot-sizing, allocation, etc.
- Stochastic and multi-dimensional procedures are of especial interest for future research.

Bibliography

1. Tsadikovich, D.; Levner, E.; Tell, H.; Werner, F.. **An Integrated Approach for Maintenance and Delivery Scheduling in Military Supply Chains**, Faculty of Mathematics | OvGU **Series:** 2015-20, Preprint

- (to appear in *Int. J. Prod. Res.*, published online)

Thank you!