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ANSI/ISA 95 FINAL CAPACITY SCHEDULING FOR SOFTWARE INDUSTRY

P. Vasilev

Department of Industrial Automation,
University of Chemical Technology and Metallurgy,
8 Kl. Ochridski, 1756 Sofia, Bulgaria
(e-mail: plamenvasilev2@gmail.com)

ABSTRACT: The Scheduling in Software Industry is a matter that caused many studies and various approaches for solving this problem in the past few decades. Neither of these approaches uses as a framework the industrial standard ANSI/ISA 95 in which the models for Capability, Scheduling and Execution are tightly connected with the needed Resources and their availability. In this research the matter of Final Capacity Scheduling using the standard ANSI/ISA 95 as a framework is discussed. Examples are given for using ISO 22400 Key Performance Indicators in the calculation of some important for the Scheduling process parameters.

Keywords: ISA-95, MES/MOM, Personnel Model, Scheduling, Lead Time, Capacity, Software Industry

1. INTRODUCTION

Estimating Tasks in Software Industry for the purpose of Scheduling is a matter that drives along with the Software Industry itself from its beginning. The difficulties of estimation are related to many factors and uncertainties mainly resulting of the relativity of software development's products and their virtual nature.

In contrast to conventional manufacturing industry, where the Lead Time for a given task is calculated, based on productivity of a machine and other tangible values as dimensions and proportions of a product, the scheduling process in Software Industry cannot be performed with such accuracy and certainty at all.

Many approaches have had considered using heuristics and exact predictions of Lines of Code (LOC) that must be written. These approaches assume either a backlog of Tasks categorized by some similar characteristics for every new Task, which will be useless in case there is something new that have to be made, or presume that everything that is written on each step of the Software Development Process is code and it takes the same amount of time to write a line of code each time.

2. AGILE SOFTWARE DEVELOPMENT VS. KANBAN

The agile approaches are based on collectively defining User Stories that have to be independent, estimable, small sized and testable functionalities that the customer (or the user) wants to acquire and have value for him. User Stories are estimated by the Agile team using Story Points which give rough estimation of the size and complexity of the User Story. Usually Story Points are measured in man-hours, but it is not a value of User Story itself but of the effort needed for it to be done. User Stories are break down to Tasks, which progress is discussed in in daily meetings.[6,7]

Another approach is Kanban Software Development, which differ from Agile approaches as Scrum and Extreme Programming (XP) mainly in the way of Planning & Scheduling. Originating from manufacturing (TPS), Kanban Software Development uses Lead Time as a base for planning the activities that have to be executed. The Lead Time may be approximately set for example by executing a spectral analysis on a Task backlog and diversifying them by similar characteristics. [9,10]

3. ANSI/ISA-95

ISA-95 is the international standard for the integration of enterprise and control systems. ISA-95 consists of models and terminology. These can be used to determine which information, has to be exchanged between systems for sales, finance and logistics and systems for production, maintenance and quality. This information is structured in UML models, which are the basis for the development of standard interfaces between ERP and MES/MOM systems. The ISA-95 standard can be used for several purposes, for example as a guide for the definition of user requirements, for the selection of MES/MOM suppliers and as a basis for the development of MES/MOM systems and databases.[1,2]

Personnel Model in ISA-95

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The Personnel Model in the standard defines the connections between the objects: Person, its properties and Personnel Class (Roles) in the production and properties of the class. In the Personnel Model are also defined the objects for Personnel Qualification Test Specification and the Qualification Test Results. In the model on Fig. 1:

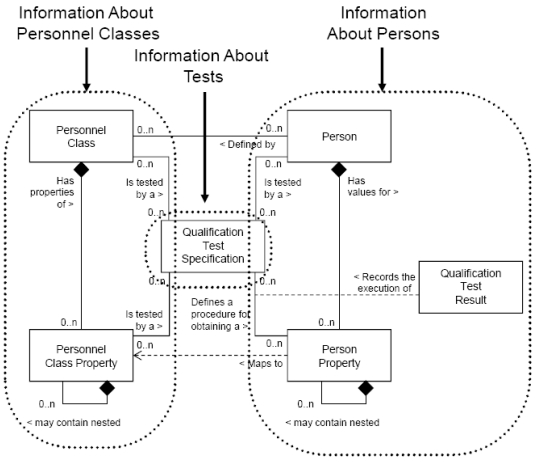

Fig. 1 UML Diagram of Personnel Model

Person is a specifically identified individual.

Person properties may include the current availability of a person and other current information, such as location and assigned activity, and the unit of measure of the current information.

Personnel class is a means to describe a grouping of persons with similar characteristics for purposes of scheduling and planning.

Each personnel class may have zero or more recognized properties. Examples of personnel class properties for the personnel class "operators" may be "class 1 certified," "class 2 certified," "night shift," and "exposure hours." Production requests may specify required personnel class property requirements for a product segment.

Qualification Test Specification may be associated with a personnel class property or person property. This is typically used where a qualification test is required to ensure that a person has the correct training and/or experience for specific operations. A qualification test specification may test for one or more properties.

Qualification Test Result records the results from a qualification test for a specific person.[2]

Based on the Personnel Model a *Qualification Test* is made to correspond to a specific Personnel Class properties that each Person, which is a member of this Class must achieve. The Qualification Test Result may be further interpreted for providing specific certifications or classifications, needed for preparation of *Production Schedule* as *Personnel Requirement* and *Personnel Requirement Properties*.

For Example: there may be a requirement for one mechanic with a specified level of certification available five hours after start of production. There would be one personnel requirement for the requirement for the mechanic and two personnel requirement properties, one for the certification level and one for the time requirement. [3]

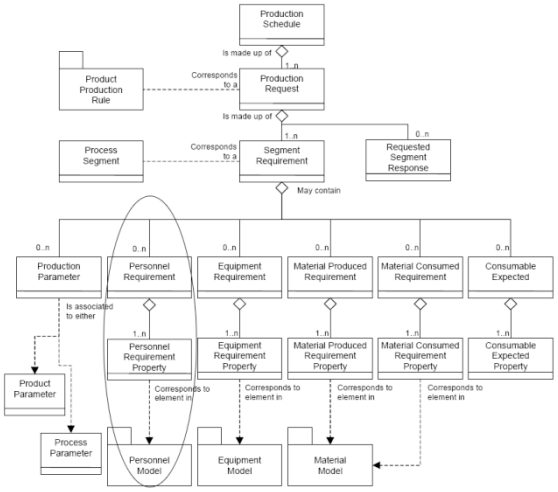

Fig. 2 UML diagram of Production Schedule Model [2]

Personnel Model Attributes

The second part of ANSI/ISA-95 standard defines the attributes of the object information model. The attributes represent a minimum set of industry-independent information, attributes can be added depending of the needs of specific production. Examples of additional attributes that can be added for Qualification Test Specification, which is related to a property of the Personnel Class or to Person Property, can be: "Qualification Type" with values – "Operational", "Safety", "Foreign Language", etc. or "Validated by" with values – Name of responsible person or "Certification" with values "ASP.Net", "JavaScript", etc.

The attributes given for Qualification Test Specification are:

- Name: identifies the test for certifying one or more values of the person properties;
- Description: Additional information;
- Version: for more than one version of qualification test specification.

The attributes given for Qualification Test Results are:

- ID: A unique instance identification that records the results from the execution of a test identified in a qualification test specification for a specific person;
- Description: Additional information;
- Date: Date time of the test;
- Result: Pass/Fail, Alphabetical score, etc.;
- Result Unit of Measure
- Expiration: Date time of expiration, may be used for appointing next test (periodically testing of personnel).[3]

Qualification Tests Specifications

The Qualification Test Specifications' purpose in a MES/MOM system is to provide the necessary tool for tracking and tracing personnel knowledge and skills, which correspond to specific personnel class (Software Engineer, QA Engineer, etc.). For each personnel class there may be several test specifications depending of which personnel class property the test is related to. For Example: a Software Engineer may need operational certificate, "ASP.Net" certificate and/or "JavaScript" certificate in his every-day work, so he must pass an exam every year (or six months).

The Qualification Tests Specification is important to the tasks scheduling process. It is a "building block" of the Personnel Capability and thus is connected to the Personnel Requirement. [2,3]

4. PERSONNEL CAPABILITY AND CAPACITY SCHEDULING

The Capability in the standard ANSI/ISA 95 is defined as a collection of information about all available resources for production for selected times. The availability of resources depends on whether or not they correspond to the Segment Requirement for a given Production Request. It includes Personnel Capability, Equipment Capability, Material Capability and Process Segment Capability, as shown on Fig. 3:

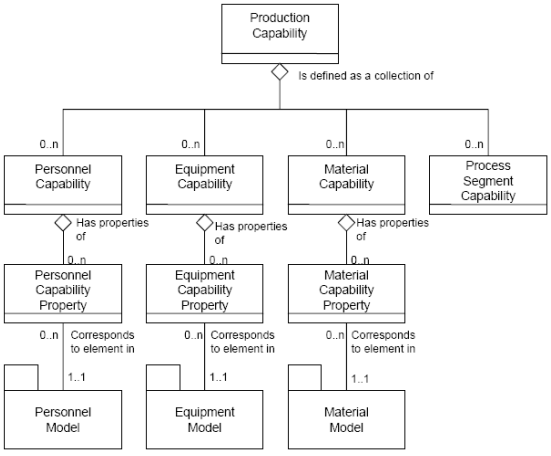

Fig. 3 UML diagram of Production Capability Model

In the Software Development processes the most valuable resource is Personnel. From the Personnel Capability, which includes all the Capacity of Personnel, depends the whole Production Capability, hence the Production Scheduling and Production Performance.

While the Capability is used to provide information about what resources may be used, the Capacity gives information about current situation of the resources and their utilization. It depends more of the Calendar time (working and not working time) and the tasks already committed with given resources.

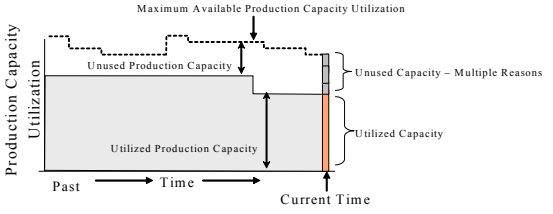

Fig. 4 Capacity Utilization

For Example: Personnel Capability gives information for the resources that are needed for a given Production Request. If there are two software engineers capable to work on this request and their Availability is four hours each. When one of them is assigned for the requested work on the given Process Segment, the Capacity needed for the work, will be changed from Available to Utilized (Committed). [4,5]

Lead Time Calculation

When a Production Request is entered in the system, depending on its type and complexity, it is estimated (with Story Points) and broke down to Tasks (Work Orders). All the Tasks of each type in the system are weighted by coefficient, which is a result of a spectral analysis. The Tasks duration (Standard Time) is then calculated as:

$$\text{Standard Time} = \text{Story Points} * Kw \quad (1.1),$$

Where Kw is the Weight Coefficient, calculated as a result of the spectral analysis.

Having the Standard Time of Tasks is not enough for calculation of their Lead Time. In the software development process Tasks duration during execution vary, depending on the Person assigned and his Performance. The most important indicator of the Performance is Overall Equipment Effectiveness. It includes productivity, availability and the quality rate of the Person.

$$\text{OEE Index} = \text{Productivity} * \text{Availability} * \text{Quality Rate} * 100\ [\%] \quad (1.2),$$

OEE Index is calculated on a daily basis (for every working day) and the Time Series of OEE Index can be further examined [8]. Currently the implementation in the system is realized by using Simple Moving Average model for the last three values of the index [11].

$$OEE_{(SMA)} = OEE_{(d-1)} + OEE_{(d-2)} + OEE_{(d-3)} /3 \quad (1.3)$$

Therefore Lead Time will be calculated as:

$$\text{Lead Time} = \text{Standard Time} / OEE_{(SMA)}/100 \quad (1.4)$$

The following algorithm for Capacity balancing between the needed resources, based on their Capability, is made and used in practice in a MES/MOM system designed for the purpose of Software Industry:

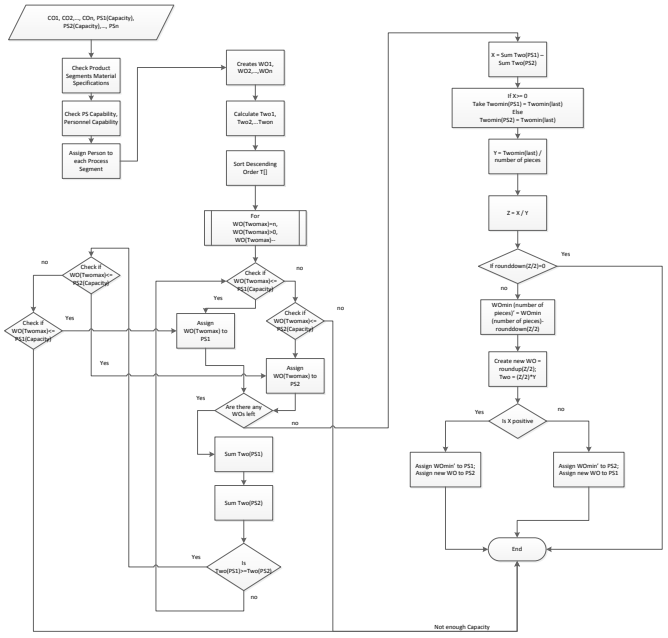

Fig. 5 Capacity Balancing Algorithm

5. CONCLUSIONS

Designing and setting in exploitation a fully operational ANSI/ISA 95 based MES/MOM system for the purposes of Software Development processes has been stimulated by the variety of advantages that this systems possess, compared to the products on the market.

Final Capacity Task Scheduling and Calendar Management are one of the advantages driving this research.

For the completion of this goal the Capacity Balancing Algorithm is made and the system is configured for dispatching Tasks between the available resources, capable of execution of this Task.

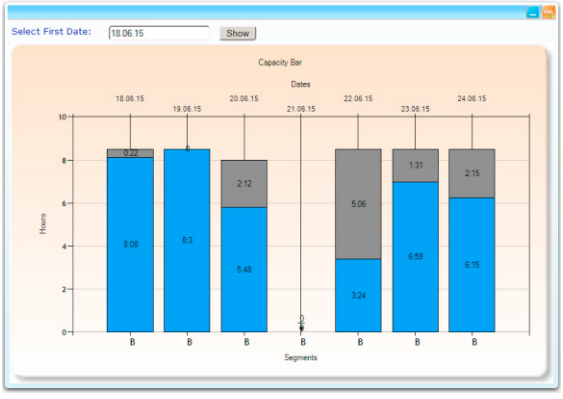

Fig. 6 Capacity Load Bar per Person [12]

The future work on this matter will be to advance the Scheduling algorithm by précising the calculation of Lead Time and introducing more specific Personnel Qualification Test Specifications.

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