Advanced Planning and Scheduling Initiative's XMAS tool: AI for automatic scheduling of XMM-Newton long term plan Commentary

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Introduction

The author presents an interesting Planning and Scheduling (P&S) framework to schedule observations for three current ESA missions namely Mars express, Integral, and XMM. But since the goal of this study was to develop a general purpose architecture to be used for single instrument observatories, I decided to critique this system by using compiled Mission Planning System (MPS) criteria that I collected from a P&S expert's course notes; by participating as co-lead on a P&S Domain Focus Group; by using comments supplied by a Users' Survey; and by using information compiled for document which discusses Operation Concepts for the Next Generation P&S Systems. All of the documentation mentioned above reflects the opinions and views of various stakeholders such as project personnel, mission operators, Flight Operations Teams (FOT)s, and science/mission schedulers in the area of P&S, during the past nine years.

In addition, I obtained feedback from Mr. Stuart Frye, the EO-1 mission engineer lead, to determine if this technology was feasible for an existing mission such as EO-1 or to NASA.

MPS Criteria

P&S Expert Course Notes

A P&S expert presented course notes that described several system design attributes which are necessary to develop a scalable and robust P&S system [1]. These five characteristics are summarized as follows. One, the system should adopt a ***client/server design*** to allow multiple users the ability to access the system simultaneously. With this type of design, the system can dynamically rework the problem as each user provides input. Two, the system should follow a ***data-centric design*** to allow for easy insertion of algorithms and models as problems change. Three, the system should implement a ***scalable Object-Oriented Design (OOD)*** to provide logical hierarchical groupings such as inheritance and segmentation for data expandability. Four, the system should include a ***plug-in-play framework*** to add or extract system components, such as Databases (DB) s to reduce dependencies on expensive Commercial-off-the-Shelf (COTS) DBs, or DB experts. Five, the system should contain a ***modular Graphical Users Interface (GUI) design*** to easily input scheduling rules, interpret output scheduling rules, and perform extensive constraint checking on scheduling rules.

P&S Domain Focus Group

I participated on a team with P&S system users whose charter was to analyze cost drivers and determine future goals for readily available P&S systems [2]. Thus, the team agreed that **configuration costs**, **initial and recurring support licenses fees**, and **training costs** were the biggest cost drivers for P&S systems. Likewise the team identified four requirements which P&S systems should address for multi-mission support. The first requirement is to develop **common data stores** to enable unlike missions to share data. The second requirement is to develop **standardized mission interfaces** which allow different types of compliant systems, to communicate with the common data stores and with each other. The third requirement is to develop **interchangeable databases** such that data storage can be selected based on budget, preference, and need. The fourth requirement is to develop **abstract planning capabilities** which allow operators to specify high level goals and to execute the low- level activities necessary to accomplish the goals.

Users' Survey Results

Several years ago, the Mission Applications Branch (MAB) conducted a users' survey of homegrown P&S systems to learn how customers used them and whether or not the systems met the customer's requirements [3]. These customers included FOT personnel, science planner and schedulers, as well as mission planner and schedulers from the SOHO, TRACE, TRMM, L7 and Terra missions to name a few.

Again, these customers provided very useful suggestions regarding P&S multi-system development. The first suggestion was to **design seamless systems** to allow integrated subsystems to work as a cohesive unit. The second suggestion was to **budget for a developer** to automate routine tasks during the operational and maintenance phases of the mission, when these tasks become easier to identify. The third suggestion was to **maximize the use of technologies** such as web, Interactive Data Language (IDL), and Common Data Format (CDF) to capture, process, and archive science data faster and easier. The final suggestion was to **develop web-based activity plans** to help distribute schedules and activities to a wider audience of project personnel. In fact, LRO personnel sited a need for web-based activity planning as part of their MPS requirements [4].

Operations Concept for Next Generation P&S

The surveyed missions for next generation multi-mission systems include GPM, LRO, and MMS. Their overall requirements for selecting an MPS are as follows [5]:

- ***Simplicity*** – software adopts wizards and GUIs to provide step-by-step instructions and processing results to the user.
- ***Modular*** – software provides mechanisms for configuring and customizing system components such as scheduling algorithms, models, and GUIs (commonly known as a framework).
- ***Component Reuse*** – software uses frameworks to effectively reuse software components.
- ***Low-cost*** – software requires less than one Full Time Equivalent (FTE) to operate and maintain per year.
- ***Automation-friendly*** – software contain mechanisms to automate day-to-day activities.
- ***Security features*** – software authorizes personnel to change displays or scheduling rules and enforces network security regulations.

EO-1 Mission Perspective

I obtained feedback from the EO-1 mission manager to determine if this technology would be feasible or useful to EO-1 and his comments are as follows.

The report is well written and could appear as a peer reviewed journal article. However, there is not enough detail on the actual software to judge whether or not it could be adapted for NASA use. The system is primarily setup to construct long term plans, which is great for vetting science proposals and setting up year-long high level plans that are optimized in a way that could be applied to many satellite missions.

The paper did not discuss the status of the short range planning/scheduling software or system which would be the place where the actual weekly and daily schedules are produced and from which satellite command loads are built. The long term software does not build loads, so that's one big area that makes the whole idea of exploring its utility for NASA applications pretty limited.

If there are areas where EO-1 needs to construct long term science plans that are optimal and visible/interactive to the science team, then this software could be considered, but it is not adequate to make spacecraft schedules or build loads. Furthermore, finding out more about the actual software code and architecture would be needed to make a better call on whether it could be useful to NASA.

Conclusion

The compiled MPS criteria can be directly applied to how the XMM mission features are modeled in the APSI framework. For example, the APSI integral mission scheduler component should contain a modular GUI design to input/model activities and constraints; a data-centric design to easily add algorithms; and abstract planning techniques to automatically develop low-level activities from high level goals. In addition, the criticality index, multi-objective cost function, chain observations as well as the heuristics should be developed using OOD design techniques that can easily be enhanced, tailored, or modified for multi-instrument use, if applicable. Finally, the integral mission scheduler platform should contain a framework to standardize interfaces; to easily adapt and configure the system; to automate routine tasks; and finally to authorize and enforce security regulations. Thus to ensure that your generic tool can be used to cover several aspects of scheduling for single instrument space observatory and even multiple instruments, in the future, be sure to incorporate as many MPS criteria as possible.

References

1. Hempel P., et.al. January 2000. "An Introduction to Planning and Scheduling Systems". Computer Sciences Corporation, Greenbelt Md.
2. Catena J., et.al. June 2002. "P&S Domain Focus Group Phase One Presentation". GSFC.
3. Wood T. et. al. July 2002. "Users Survey of P&S Systems for MAB". GSFC.
4. Clapsadle et. al. August 2005. "LRO's MPS Requirements". GSFC.
5. Hendicks V. et. al. October 2005. "Next Generation Planning and Scheduling Study Concept of Operations Document" Honeywell Technology Solutions Inc., Lanham Md.