ISSN:0975-9646

Dhara K.N et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (2) , 2015, 1387-1389

Target Planning System

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***Abstract*— Target Planning System (TPS) addresses the global problem of optimizing an imagery schedule to maximize the value – weighted targets that exist in today's space world. The existing planning system uses single satellite to serve the user requests which falls into the criteria of "no 100%" Coverage of targets therefore, the solution so derived may not be optimal. This causes omission of some value–weighted users. Target Planning System utilizes ground stations and on board resources efficiently to produce optimal solution. The Target Planning System ingests target collection orders, maps orders to candidate satellite sensors based on resource allocation function, calculates constraints, target opportunities for each order and determines optimal solution by incorporating multi-satellite in the architecture and by applying sequential and Random methods of scheduling techniques to plan the selection of target list against the satellites. These scheduling algorithms takes user – defined and weighted scheduling factors including cost, order priority, resource preferences, Field Of View (FOV) and Figure of Merit (FOM) into its account. The usage of multi-satellite with scheduling techniques in this field solves the problem of gaining optimal solution for value – weighted targets to have 100% coverage and maximum satellites imaging camera time.**

***Keywords*— Target Planning System; Value-Weighted Targets; Sequential Scheduling; Random Scheduling Figure of Merit (FOM)**

I. Introduction

Target Planning System (TPS) has several features, such as: (1) Resource handling (2) Order management (3) Access calculation (4) Planning and scheduling the targets. The TPS handles the resources used for image collection including satellite and ground stations. The TPS maintains a database for ingested imagery orders which can be further used for sorting, filtering, editing of related order parameters. The resource assignment function maps the orders with resources that are capable of meeting order parameter requirements including image type and availability of satellite. TPS access calculations cover all orders included in the planning run and will determine access opportunities to each candidate sensor resource for each order. Constraints applied to access calculations include daylight i.e. Panchromatic and Multi-Spectral image orders, sensor field-of-view (FOV), spacecraft and/or sensor off-nadir agility, and order resolution such as ground sample distance (GSD). Accesses are calculated for the full planning period. The order collection opportunities determined through the access calculation process are the raw material for the scheduling function. Each order collection opportunity is given a desirability priority based on time and resource preference and cost. These desirability priorities are used by the scheduling algorithms to optimize the schedule solution.

Planning will generate opportunity scenarios by predicting available access opportunities for the entire specified target list. Each selected order in the target list will be processed to build the TPS planning target database and assign candidate satellites for collection. Access scenarios are determined i.e. total number of passes expected, total access time for each candidate satellite and aggregate for all candidate satellites. Access calculations will include applicable target and spacecraft constraints. Resource loading is based on cost and resource preferences. TPS resolves the conflicts of the ground station support and schedules against the satellites as the first step of the scheduling process. Resource priority and cost for satellites, sensors, and ground antennas are also taken into account when weighting the value of each pass for schedule optimization.

II. Aim Of TPS

Multi-satellite with multiple ground stations using Sequential and Random methods of Scheduling techniques in order to optimize the satellite imaging time with respect to the multi value – weighted targets.

III. TPS Using Multi - Satellite.

A. *Sequential method of Scheduling*

It is a vertical pass-wise scheduling technique followed by satellite to schedule or plan the selection of targets for serving purpose.

Let us in Table I, 1 to 9 represents the targets those have been requested for coverage by the users (Agency Users). For the maximum coverage of targets or to attain optimization of targets, multi-satellite is used, say S1, S2….Sn.

Sequential Scheduling is a day wise scheduling of targets. It Plans the selection of targets for the day with multi passes among the requested targets. The order of selecting the targets is done based on satellite characteristics such as daylight (for Panchromatic and Multispectral image orders), any light for

TABLE I
Sequential Scheduling

Satellites	**Sequential Scheduling**		
	S1	***S2***	***Sn***
Start Level	1	2	3
Level 1	4	5	6
Level 2	7	8	9

SAR sensors, sensor field-of-view (FOV), spacecraft and/or sensor off-nadir agility, and order resolution (ground sample distance (GSD)). Each target has FOM priority (look at Equation (1)) based on this priority and selection constraints the sequential scheduling algorithms will select the targets that have to be served by satellite in a day.

FOM = User Pri (t) * k1 + RequestPri (t) * k2 + SystemPri (t) * k3 (1)

In Sequence scheduling the Scheduler starts with S1 to serve the targets that have been arranged in descending order of their FOM values. S1 selects target 1 then selects 4 and 7. The rest of the unselected targets are given to the other satellites that are in sequence, to cover the targets. The set of target selection would be completed by looking at the priorities of the targets in the unselected list. It generates only one Scenario at a time. This scheduling technique process runs in auto mode.

B. *Random method of Scheduling*

Random Scheduling allows shuffling the order of Satellites or FOM's of the targets for better acquisition of targets for the user selected satellite satisfaction factor. This is a horizontal Grid wise scheduling where the selection of targets is based on level wise as shown in Table II. Each level is considered as Grid. Here also the targets are selected based on its FOM.

TABLE II
RANDOM SCHEDULING

Satellites	Random Scheduling		
	S2	***S1***	***Sn***
Start Level	1	2	3
Level 1	4	5	6
Level 2	7	8	9

This Random Scheduling runs both in Auto as well as Manual mode. Running in the auto mode would generate number of scenarios. Consider for example there are 3 satellites S1, S2 and S3 there can be (2^n-2) possible combinations, where 'n' is the number of Satellites. Say {1, 2, 3} being Scenario1, {3, 2, 1} being Scenario2, {2, 3, 1} being Scenario3 and so on. Random Scheduling will produce multi scenarios to the planner. The so generated Scenarios are left to the Schedule manager to select the best feasible Scenario.

Random Scheduling in manual mode would allow the Schedule Manager to raise the FOM value during emergency or urgent requests. This attains dynamicity in scheduling the targets which generally means the Satellites can randomly select the targets based on its FOM value.

IV. SCHEDULER – SR ALGORITHM

1. Initialize the target values from Common Database.
2. Select option of schedule
    a. Sequence Scheduling
    b. Random Scheduling
3. For Satellite (S1,S2,…..,Sn)

    Queue1 order Pri [ ] = FOM values in descending

    Queue2 order imaging time [ ] = Duration of target (Ascending order)

    Queue3 LatLong [ ] = Latitude and Longitude values in Descending order
4. Check the Accessibility/maneuverability for the Targets by satellites[ ] {S1,…Sn}
5. Pick the strip/target[ ] which are Accessible
6. Repeat same with "n" strips of Satellite [ ] Capacity.
7. End Generate the Multi-Scenarios[ ]

V. RESULTS AND DISCUSSION

TABLE III
COMPARISON OF SEQUENTIAL AND RANDOM SCHEDULING

Period	**No of Satellites**	**Targets**	**Sequential Scenario**	**Random Scenario**
1 day	3	100	3 scenarios *16 Strips	L(x) scenarios*16 strips

The Table III shows the comparison of Sequential and Random scheduling techniques. In a day, with three Satellites and 100 targets, Sequential Scheduling encounters only 3 scenarios with the coverage of 16 strips whereas Random Scheduling encounters L(x)[Scenarios] for the coverage of 16 strips, where L(x) is as shown below;

$$L(x) = -1/2 (x^2) + 9/2 (x) - 3 \quad (2)$$

In Equation (2) variable x represents number of satellites, in our example x value holds for only 3 satellites. This is a Lagrange polynomial equation to fit the number of satellites to the number of scenarios. The graph is as shown in the Fig.1, where x axis represents Satellites and y axis represents Scenarios.

Though some of the acquisitions made by Sequential and Random Technique look similar, the main difference lies in "time". Consider a scenario (refer Table 1) where target 1 has requested for Satellite S1 and assume it is in the 9:30AM orbit and S2 in 10:00AM orbit and also assume target 1 wants to get served at 10:00AM and target 2 at 9:30AM then Random Scheduling would be best as it involves shuffling of Satellites. This generally means S2 can be sent to 9:30AM orbit and S1 to 10:00AM orbit which is actually gain in time. User Satellite selection can be fulfilled in optimal percent when compared to Sequential scheduling.

The same case in Sequential Scheduling would result in either early gain or delay. For example, target 1 wants to get served at 10:00AM and Satellite S1 is at 9:30AM orbit this leads to early gain in time i.e. early servicing by half an hour. Consider the same case where Satellite S1is at 11:30AM orbit then there is a delay of 1hr 30min. There is either gain or delay in Sequential Scheduling. When it comes for "time" in space world, it must be taken care that everything happens at right time.

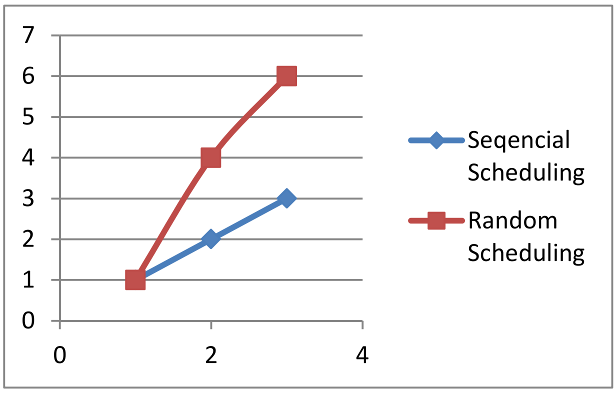

Fig. 1 Comparison of Sequential and Random Scheduling

VI. CONCLUSION

Target Planning System utilizes ground stations and on board resources efficiently to produce optimal solution. The Target Planning System ingests target collection orders, maps orders to candidate satellite sensors based on resource allocation function, calculates constrains, target opportunities for each order and determines optimal solution by incorporating multi-satellite in the architecture and by applying sequential and random methods of scheduling techniques to plan the selection of target list against the satellites. These scheduling algorithms takes user – defined and weighted scheduling factors including cost, order priority, resource preferences, Field Of View (FOV) and Figure of Merit (FOM) into its account. The usage of multi-satellite with scheduling techniques in this field solves the problem of gaining optimal solution for value – weighted targets.

ACKNOWLEDGEMENT

The authors acknowledge V.N.B.Murali Krishna for many thought provoking discussions. The encouragement and support provided by GD, MDG, Head, MPAD and CSE Department of KSSEM is highly appreciable.

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