Advanced Operations Research Techniques to Optimise Cane Rail Systems

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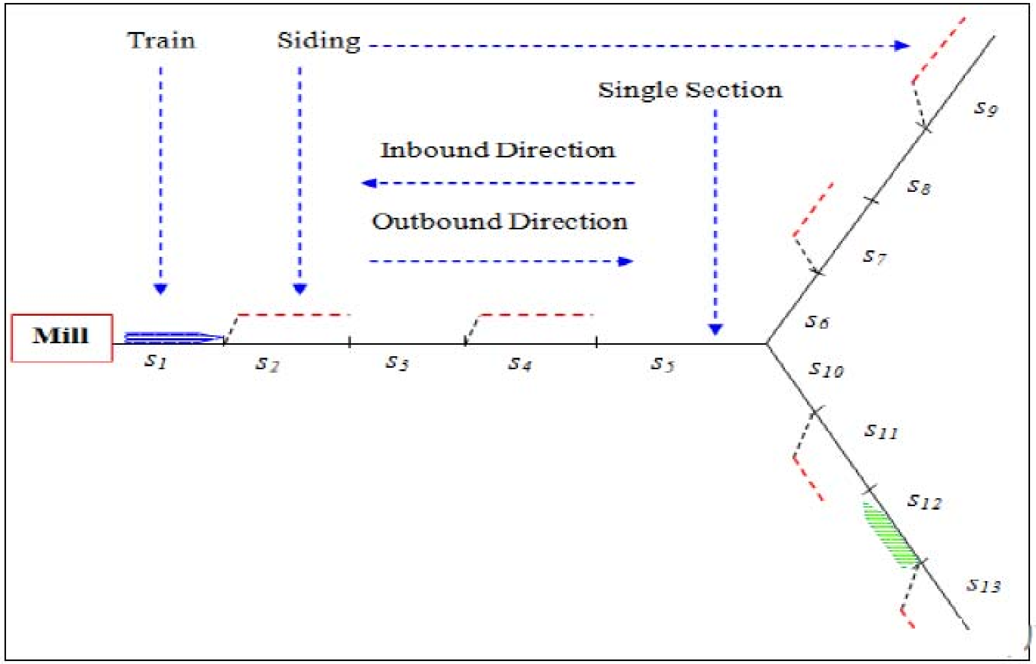
Multi Decisions in Rail Systems

- For large scale problems:
  - A decision is **easy**
    - A good decision is **not easy**
      - A near optimal decision is **hard**
        - An optimal decision is **too hard**

- Rail systems has multi decision points



The combination of the decisions =

$(d_1 \times d_2 \times \ldots d_S) \times$ *number of trains* $\times$

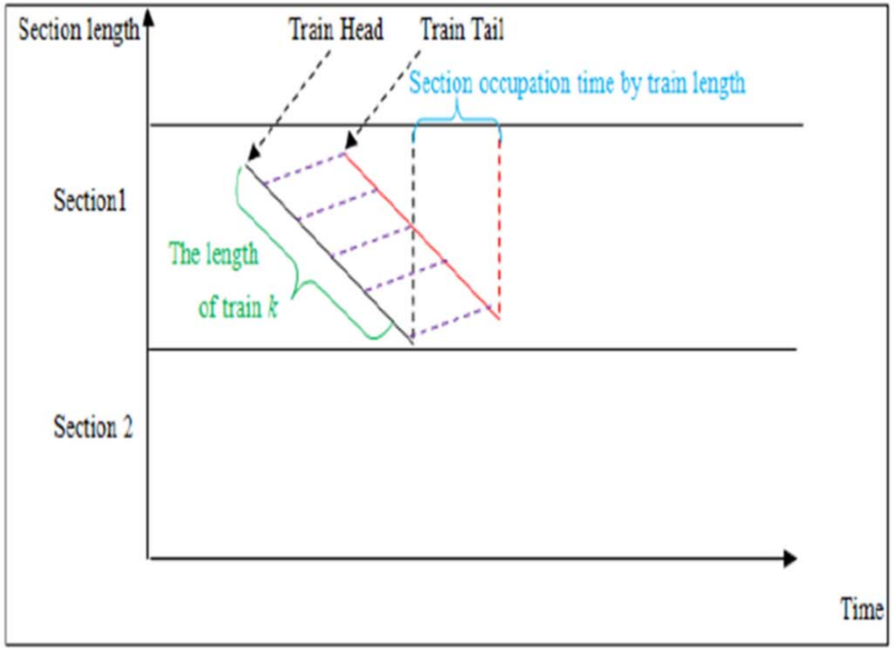
number of runs =

$(10\times8\times11\times8\times12\times8\times7\times12\times7\times8\times8\times12$

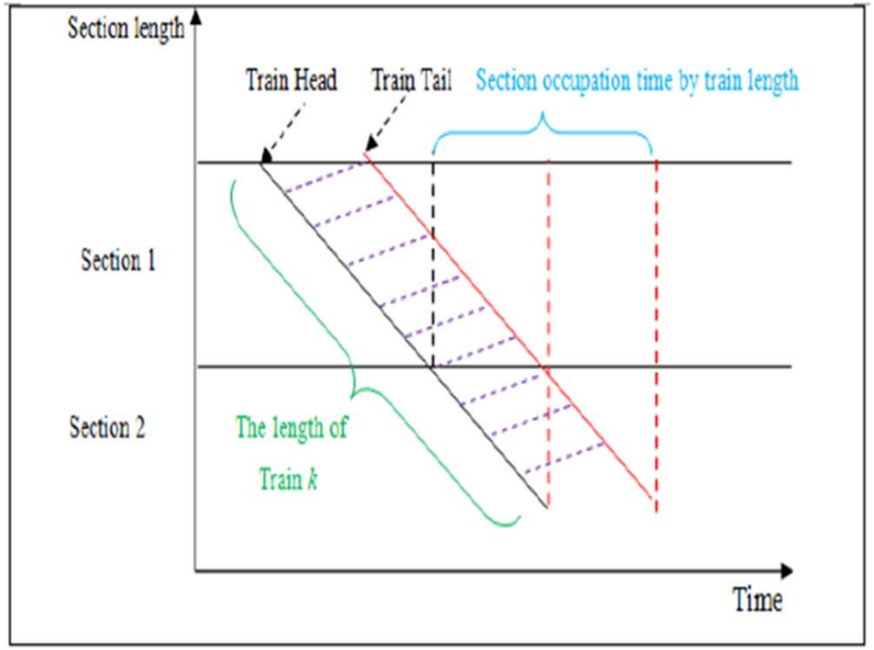
$\times8\times8)\times2\times5 = 1.95\times10^{14}$ decisions

The complexity of the rail system

Rail Complexity

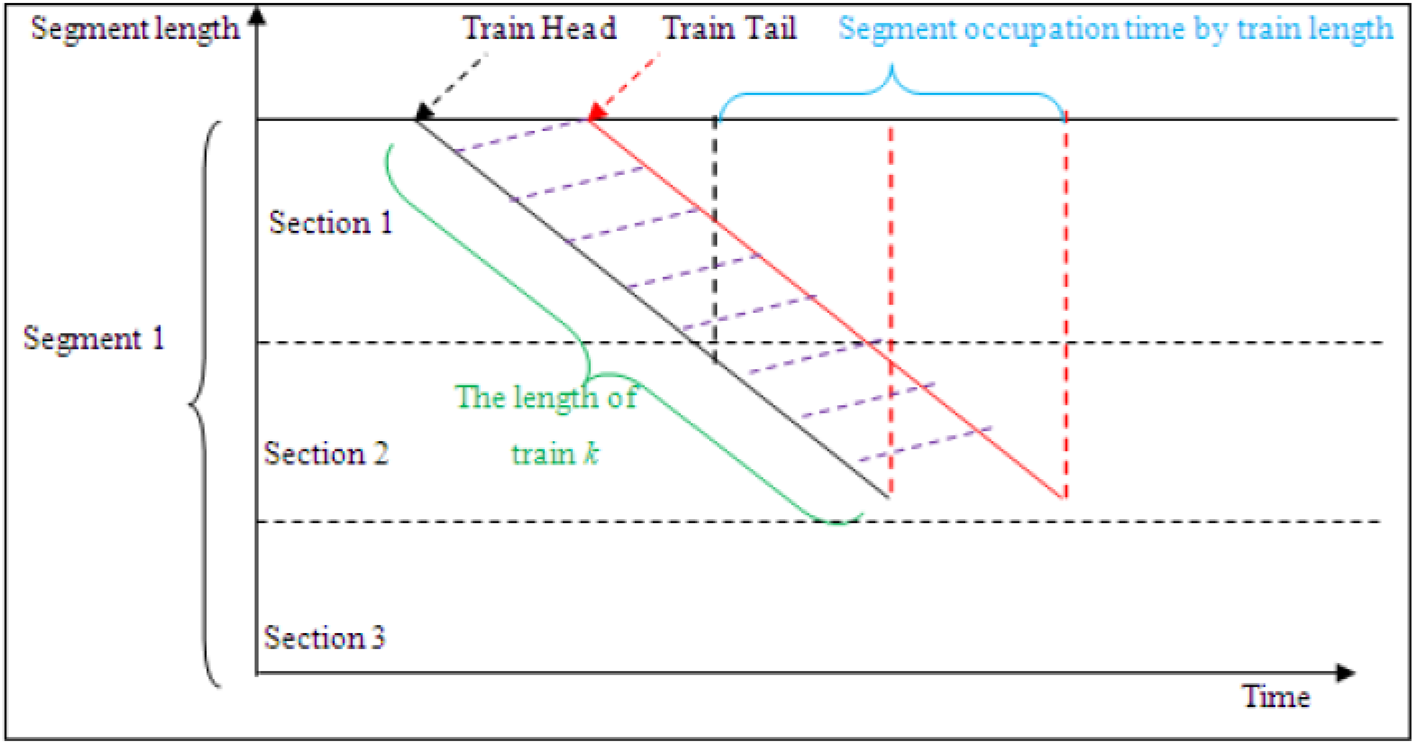


(a)Rail Standard Sections



(b)Rail Short Sections

- **Blocking Sections** is sufficient to satisfy the safety conditions in (a)
- **Blocking Sections** is not sufficient to satisfy the safety conditions in (b)

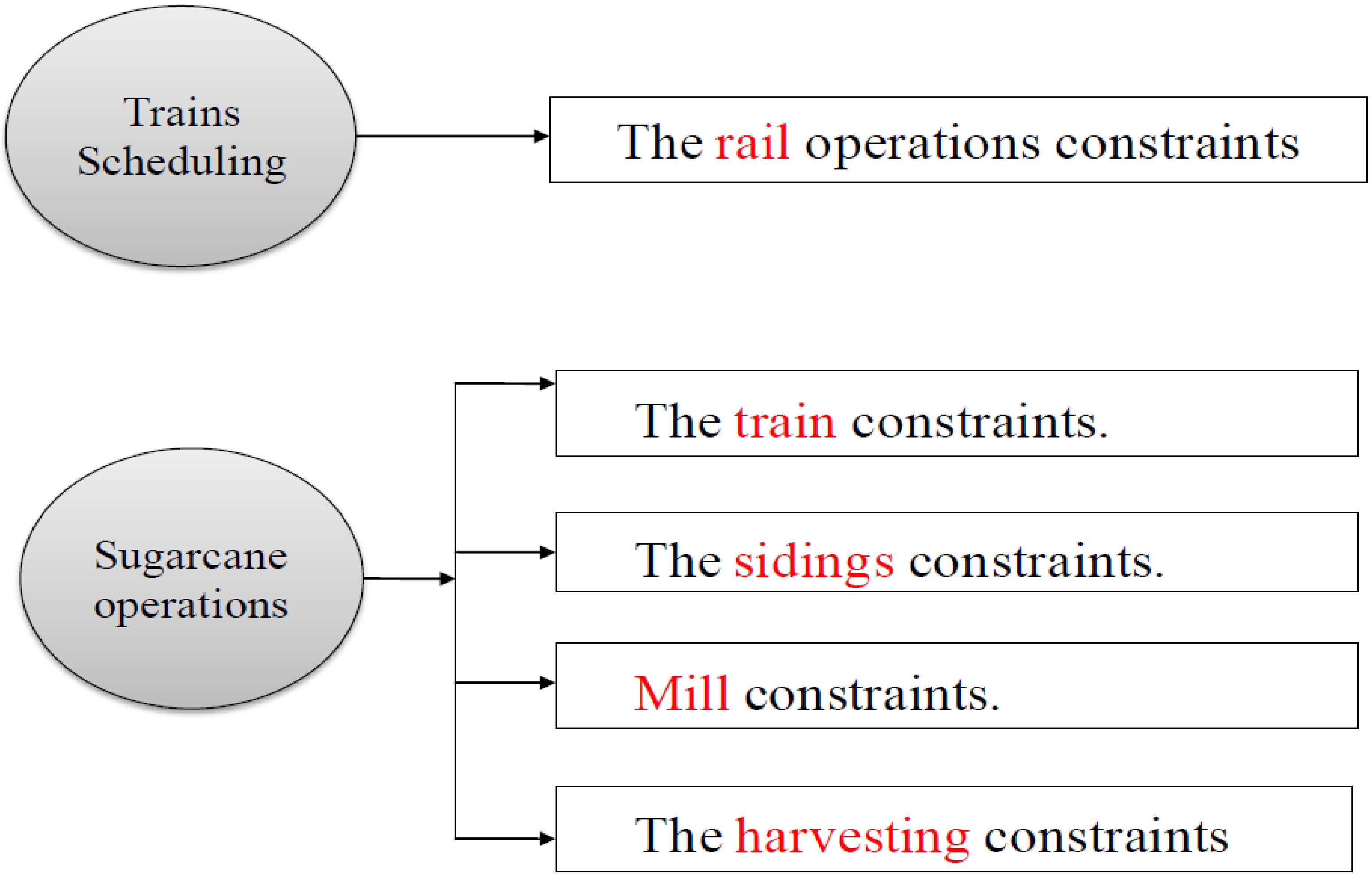


(c)Rail Segment

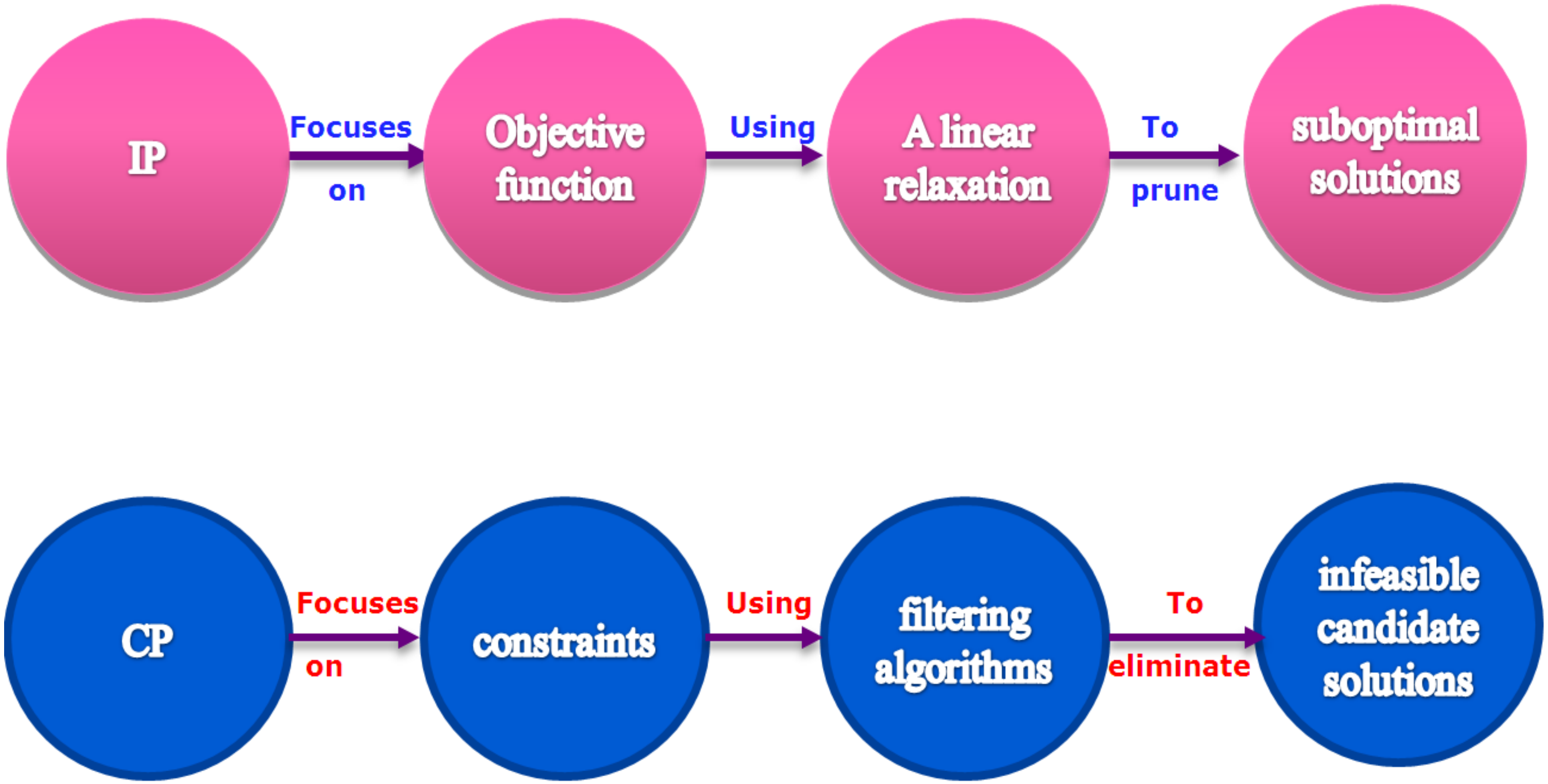
- **Segment 1** includes sections 1 and 2 as shown in (c).
- **Blocking Segment** means blocking all operations of sections 1 and 2 on this segment during

- **Rail Segment Blocking is suffici** satisfy the safety conditions in (a) ar
- **Rail Segment Blocking is necess** some of the rail segments(branches) have passing loops

The Constraints



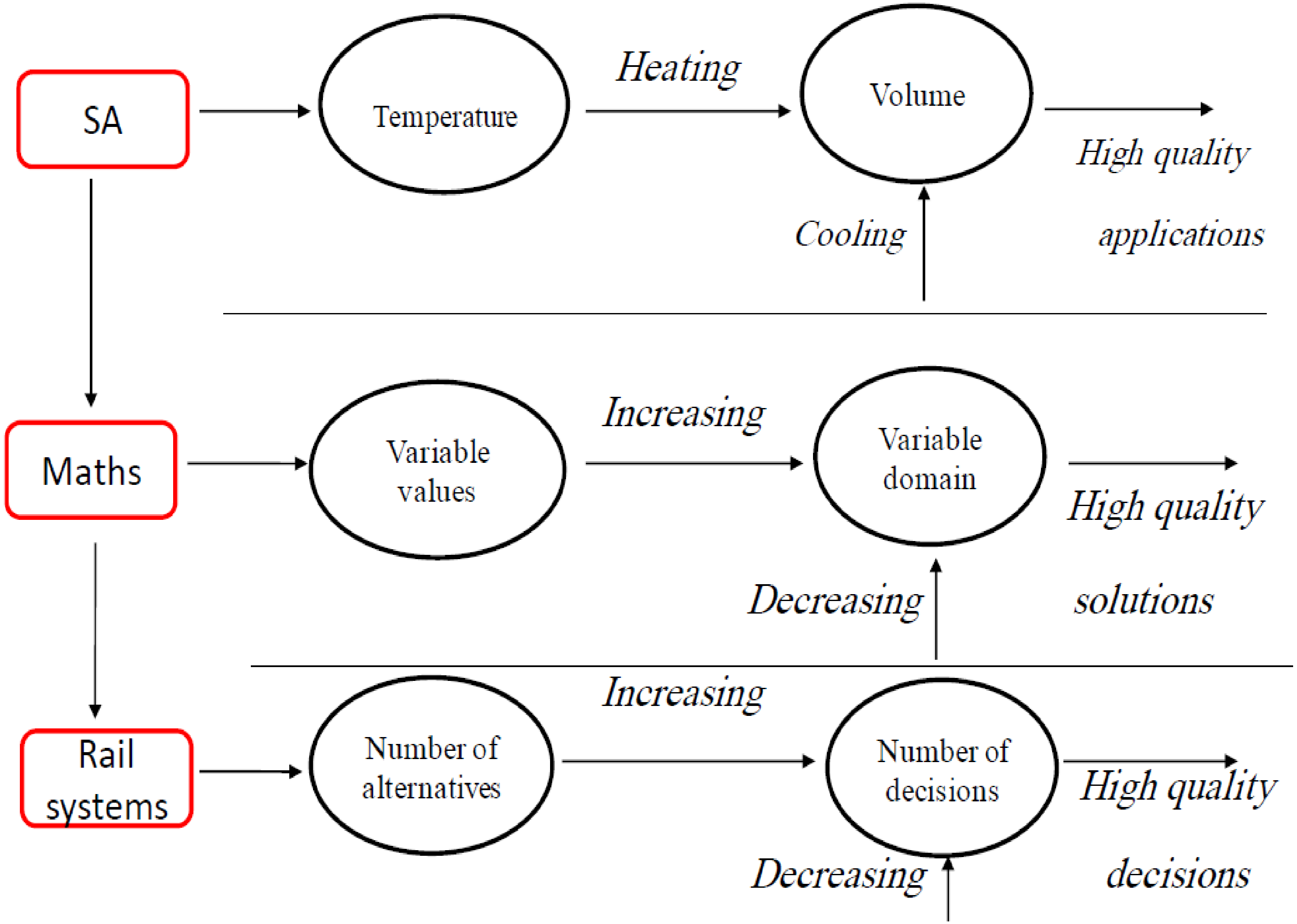
Mathematical Formulations
IP & CP



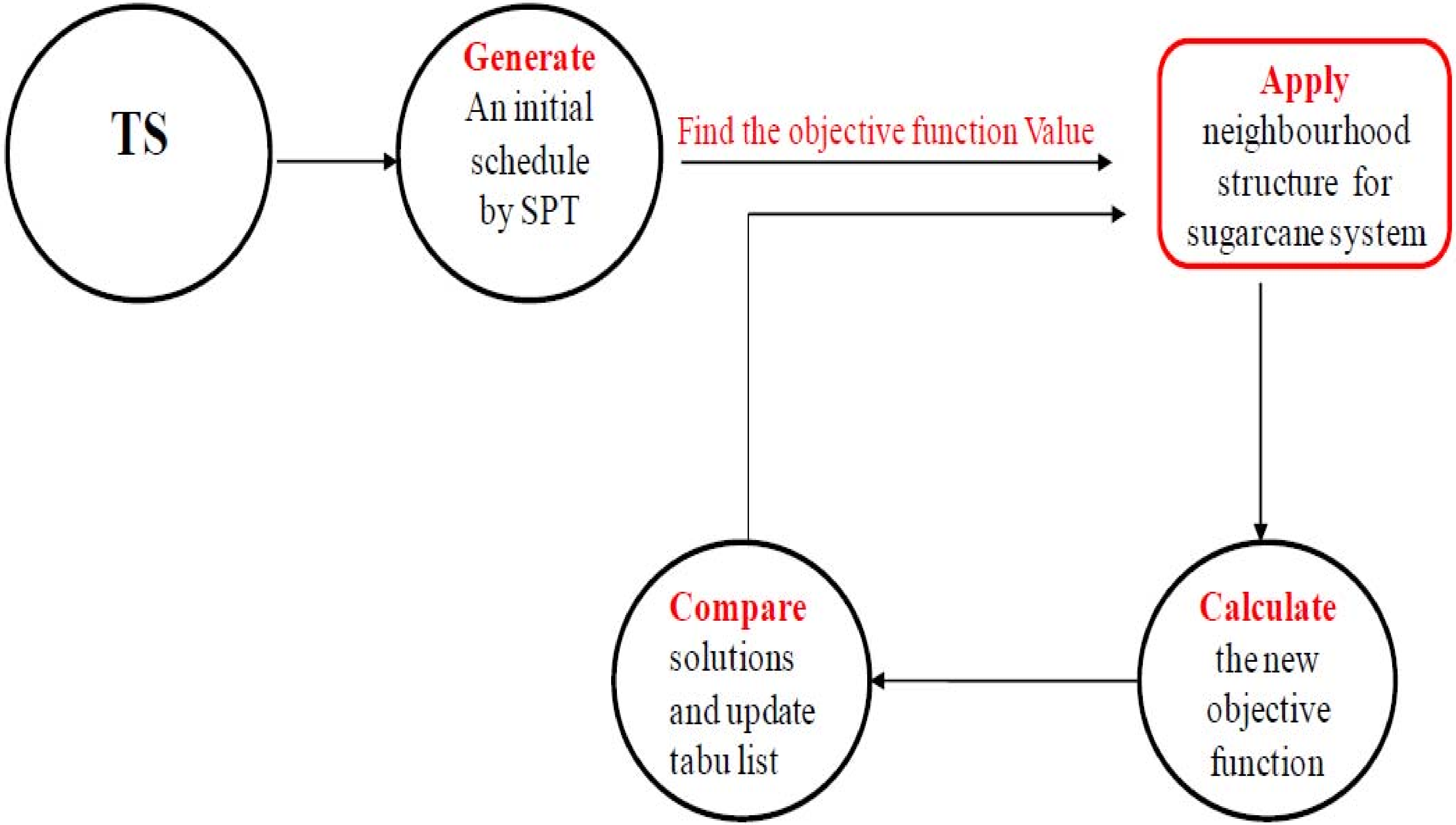
Some problems are best handled by integer programming, others by constraint programming, while some harder problems are currently outside the reach of both technologies. In our research, the benefits of both will be used.(Pascal Van Hentenryck 2002)

Metaheurisrtic Techniques for Sugarcane Rail System

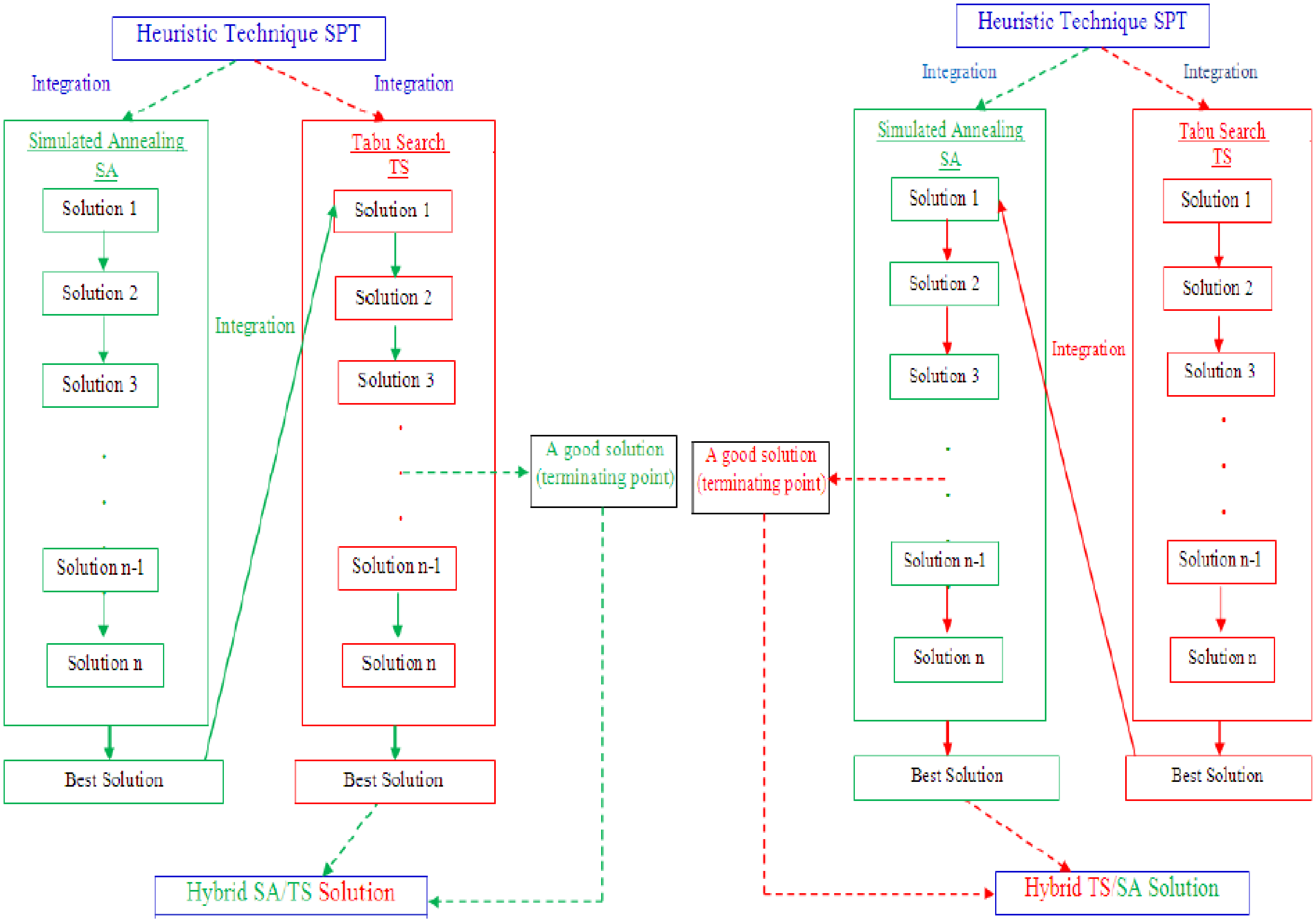
Simulated Annealing SA



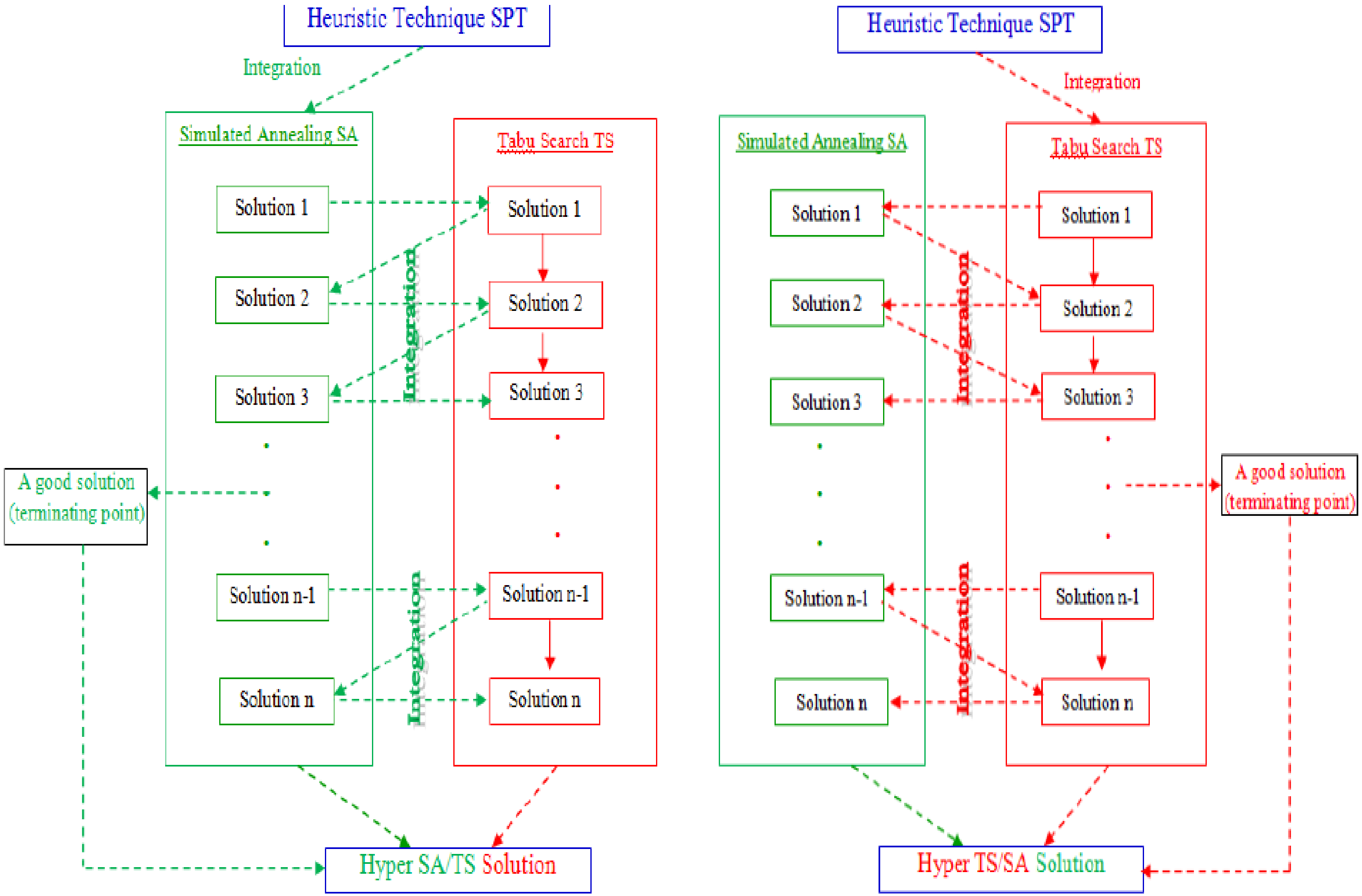
Tabu Search TS



Hybrid Metaheuristic Techniques

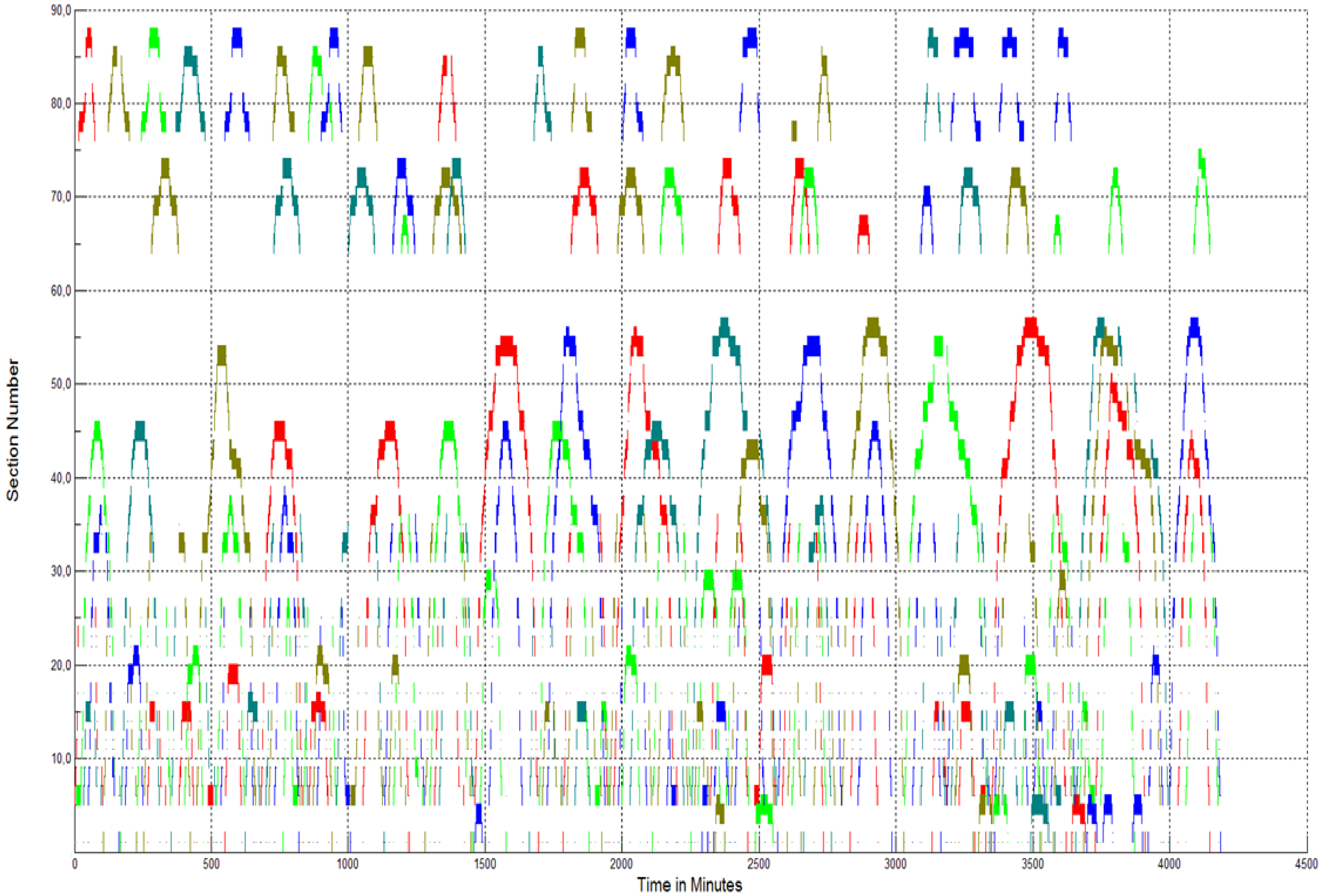


Hyper Metaheuristic Techniques



TS, SA, Hybrid, Hyper and Mixed Integer Programming comparisons

Tested cases (Sections/Trains)	Variables	Constraints	Initial solution (constructive technique SPT)	MIP-CPLEX Optimal		TS		SA		Hyper SA/TS		Hyper TS/SA		Hybrid SA/TS		Hybrid TS/SA	
				IR	CPU	IRTS	CPU	IRSA	CPU	IRSA/TS	CPU	IRSA/TS	CPU	IRSA/TS	CPU	IRSA/TS	CPU
15/4	4625	54464	12563	9	0.66	3.25	33	3.25	124	3.25	66	3.25	51	3.25	141	3.25	139
15/8	10689	166528	19257	15.3	774	11.61	188	10.62	239	12.15	170	12.15	164	12.71	448	11.215	447
15/12	18193	344112	25951	n/a	n/a	6.26	323	6.16	385	6.26	292	6.26	251	7.61	692	7.66	675
20/4	7765	96624	14288	14.1	1.67	2.53	42	2.53	152	2.53	100	2.53	83	2.53	220	2.53	224
20/8	17449	295648	20982	n/a	n/a	13.61	268	13.33	345	15.85	258	15.87	231	16.02	624	15.56	614
20/12	29053	607632	27676	n/a	n/a	6.23	448	5.92	507	7.82	454	8.49	402	8.49	1010	7.71	983
25/4	11705	150784	18234	5.99	2.11	2.28	47	2.28	196	2.82	118	2.82	96	2.28	268	2.28	261
25/8	25809	467168	24828	n/a	n/a	3.82	347	3.58	398	4.29	323	4.98	282	5.78	736	5.78	731
25/12	42313	945552	31522	n/a	n/a	4.1	547	3.61	647	5.98	538	4.365	449	4.9	1240	4.5	1221
30/4	16445	216944	23221	4.9	3.39	1.76	63	1.76	246	1.76	147	1.76	122	1.76	320	1.76	324
30/8	35769	671008	29915	n/a	n/a	4.43	437	4.43	496	4.43	384	4.5	332	4.461	905	4.43	927
30/12	57973	1357872	36609	n/a	n/a	2.96	690	2.9	769	3.87	628	3.87	544	4.59	1451	2.96	1453



Gantt chart of the solution, makespan, of 114 runs for 5 trains under limited siding capacity