SUBGOAL PARTITIONING AND RESOLUTION IN SGPLAN

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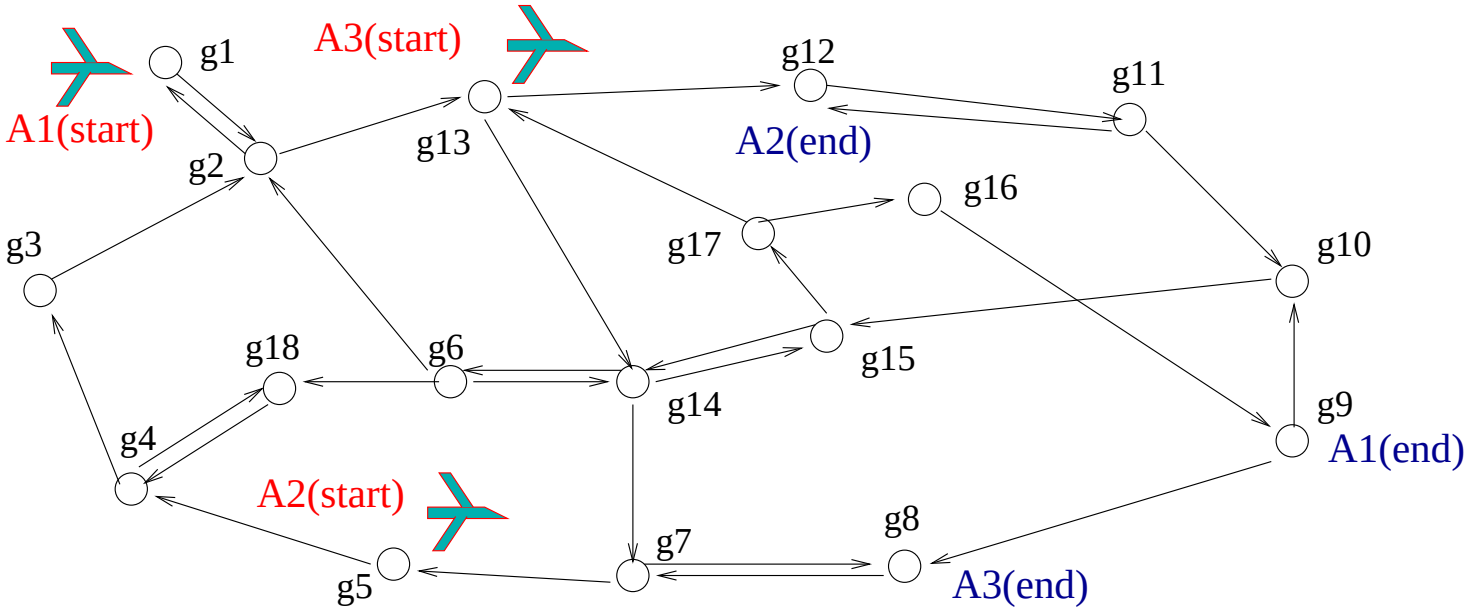
Supported by NSF IIS03-12084 and NASA NCC 2-1230

May 4, 2005

The AIRPORT-4 Planning Instance

An example Domain:

Munich Airport



Facts: at(A1,g1), blocked(g1), unblocked(g1)

Actions: move(A1,g1,g2)

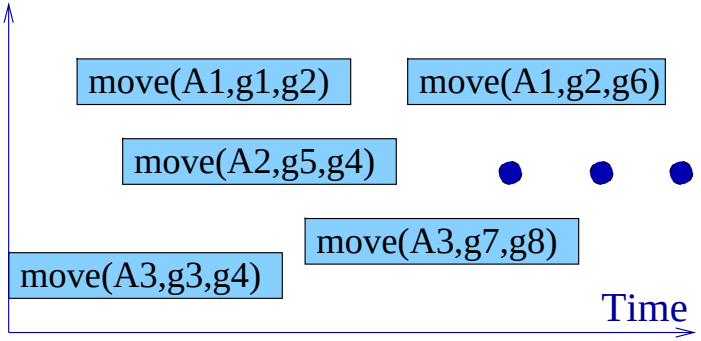
Initial Facts: at(A1,g1), at(A2,g5), at (A3,g13)

Subgoals: at(A1,g9), at(A2,g12), at (A3,g3)

Objective: minimize total time

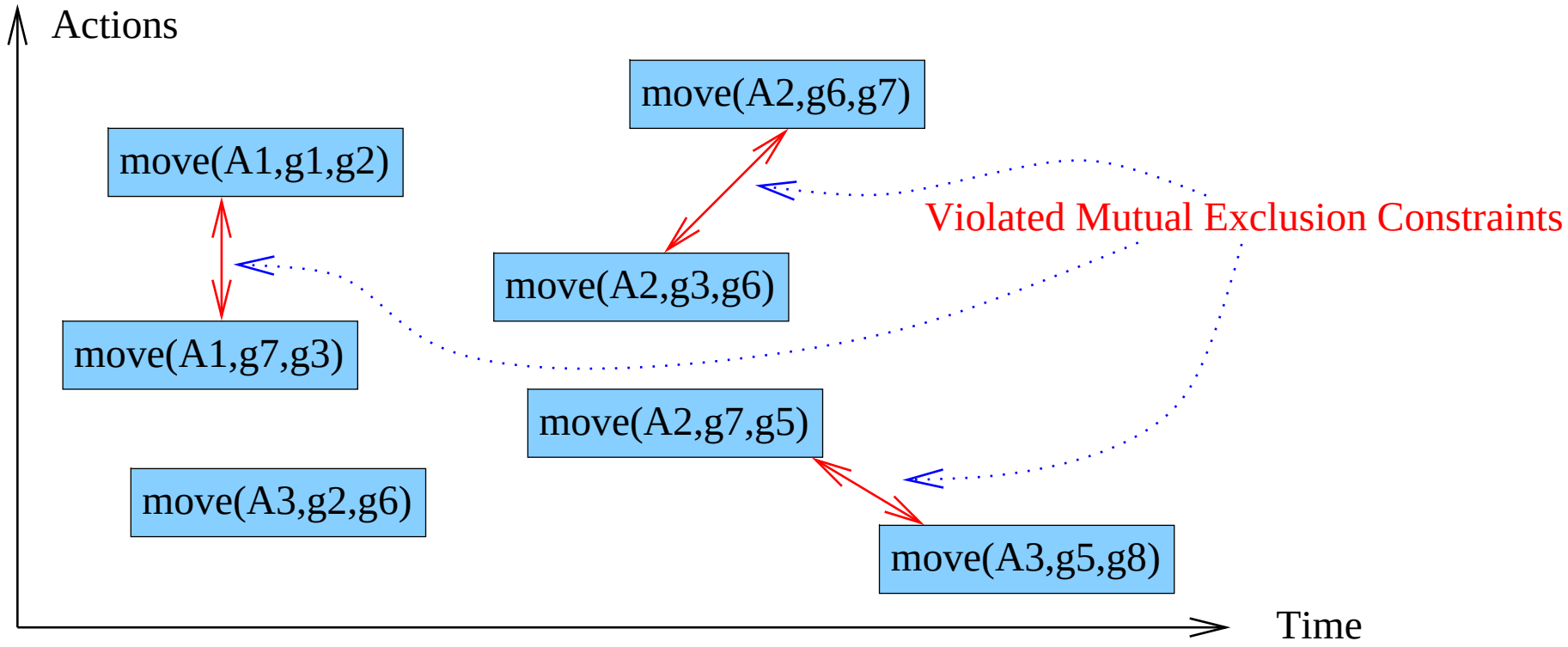
Problem specification

Planning



A Solution Plan

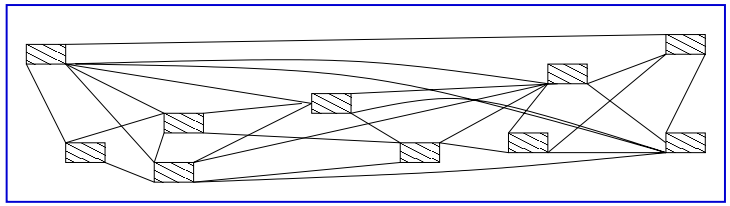
Mutual-Exclusion Constraints in Temporal Planning



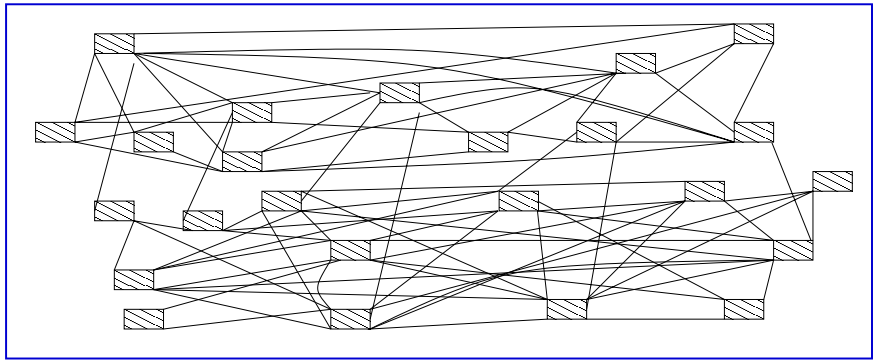
- Goal: fully automated, temporal planning
  - Original definition of mutual exclusion [Blum & Furst '97]

Mutual-Exclusion Constraints in AIRPORT-4 Instance

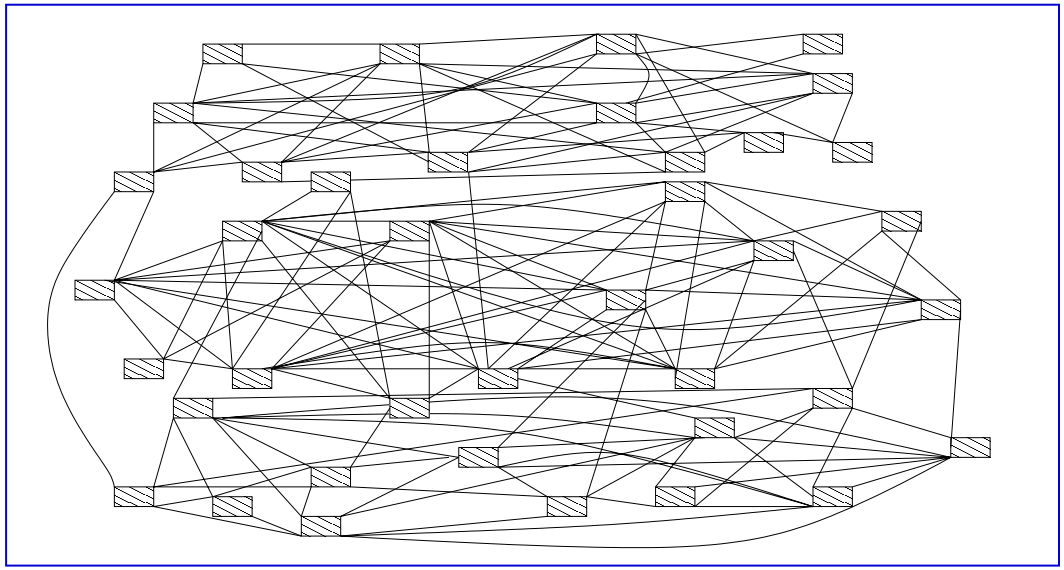
1 Subgoal (1 Plane)



2 Subgoals (2 Planes)

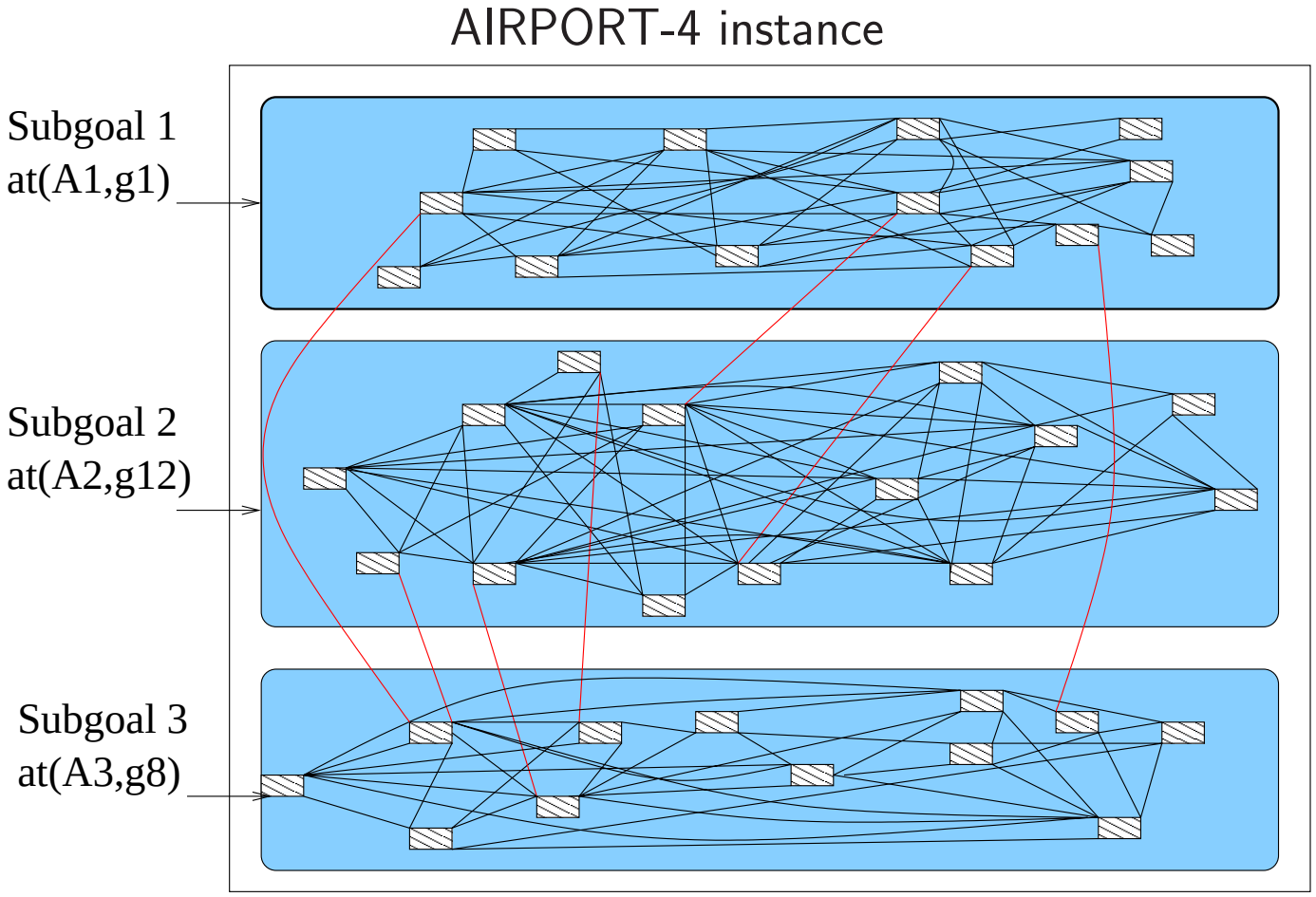


3 Subgoals
(3 Planes)



Exponentially growing complexity!

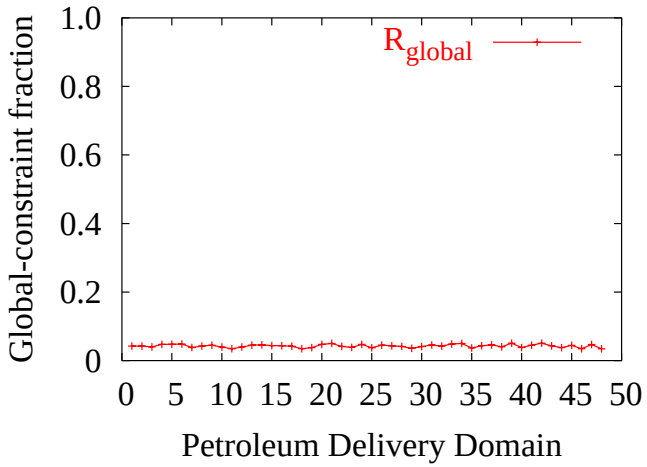
Key Observation: Constraint Locality

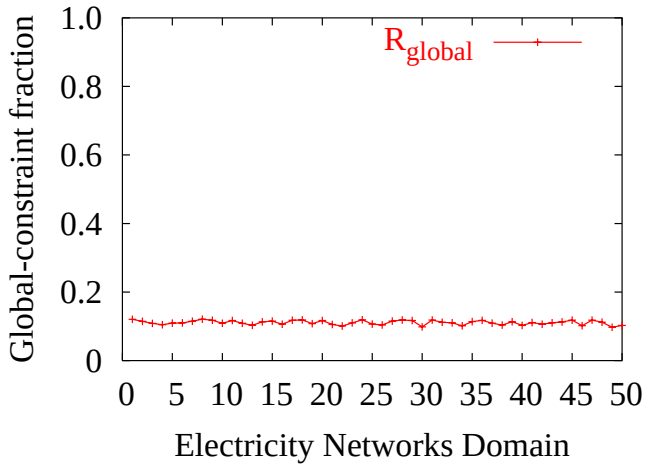


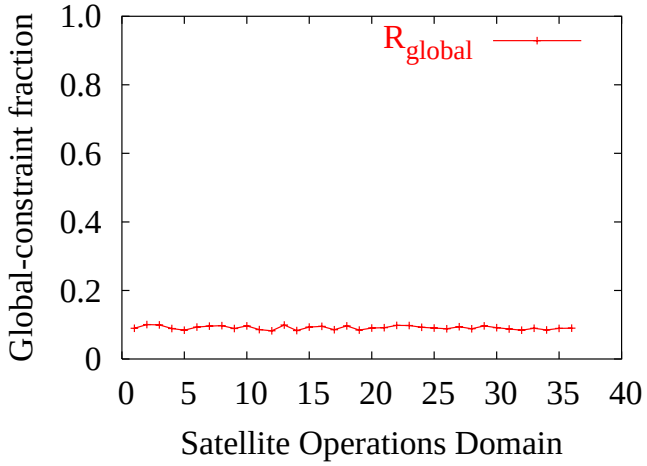
Movements of planes are largely independent and sparsely related

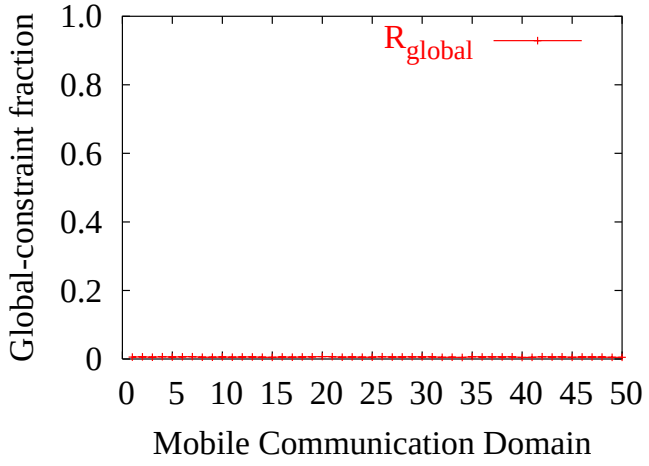
Constraint Locality in Four IPC4 Domains

- Four application domains from the 4^{th} Int'l Planning Competition (IPC4)
- Each domain has 30-50 instances





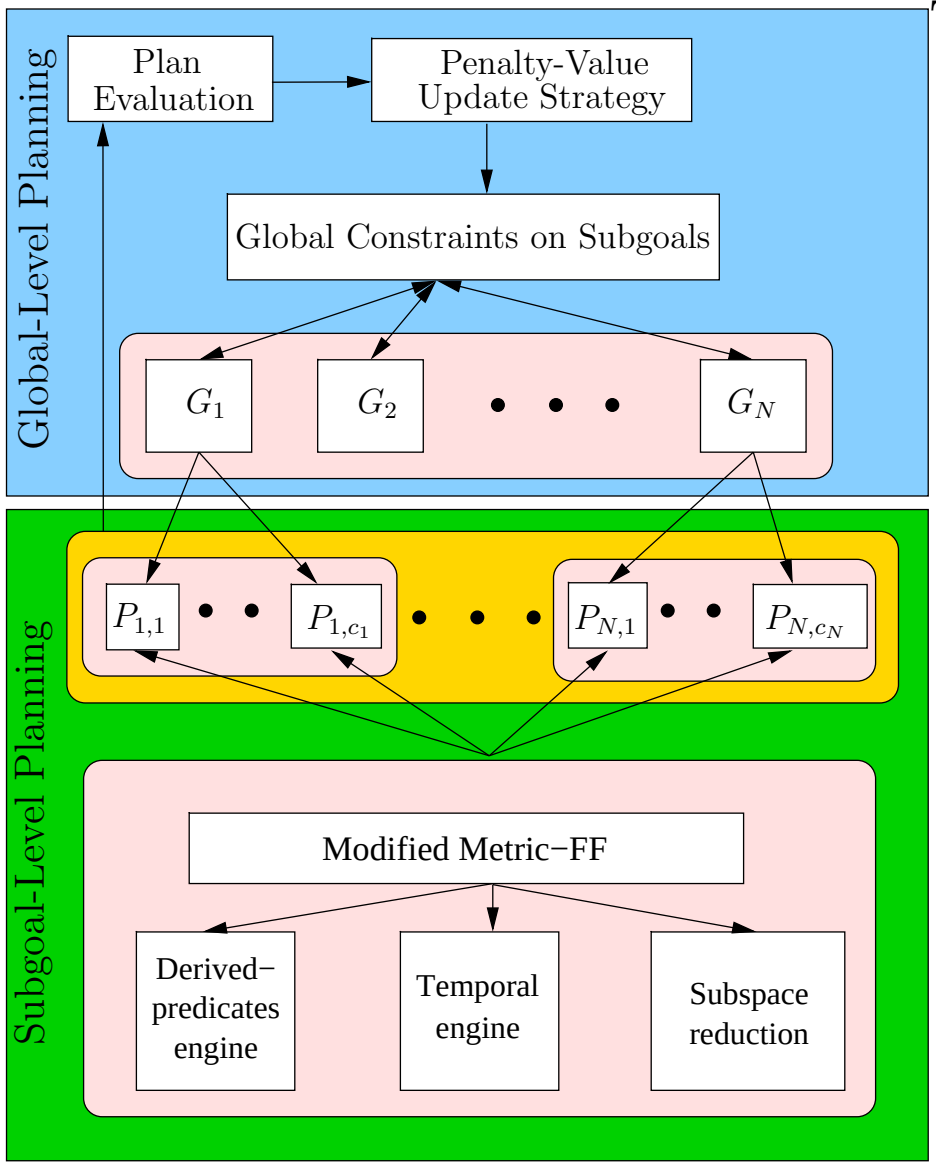




Constraint Partitioning: A Partition-and-Resolve Approach

- Proposed constraint partitioning: partition some constraints into subsets
- **Major difficulty: resolve inconsistent global constraints efficiently**
  - No domain-specific knowledge
  - No special property such as linearity or convexity
  - No continuity or differentiability
- Extended Saddle Point Condition (ESPC) for resolving global constraints
  - Based on an ℓ_1^m–1 penalty function
  - Does not require continuity or differentiability
  - Decomposed condition to prune search space of each subproblem

Architecture of the SGPlan Planner in IPC4



Techniques Studied

Global-Constraint Resolution

Producible Resources

Constraint Partitioning by Subgoals

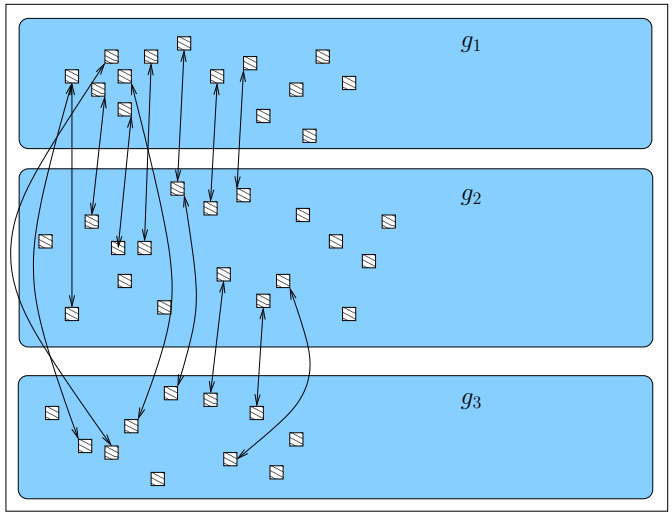
Landmark Analysis

Temporal Engine

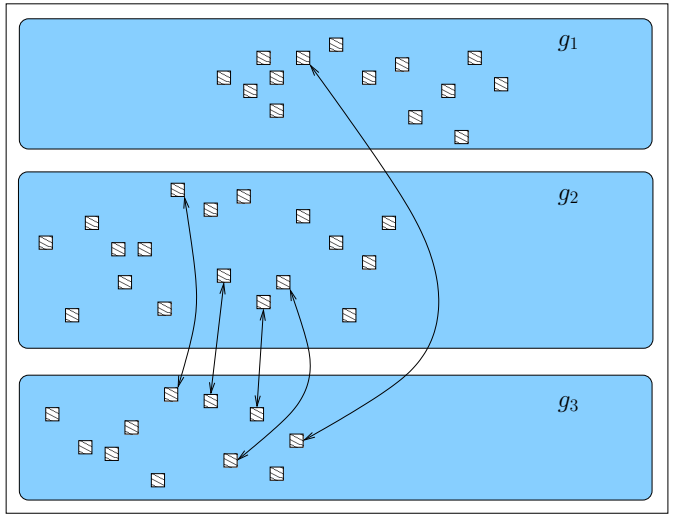
Derived-Predicates Engine

Search-Space Reduction

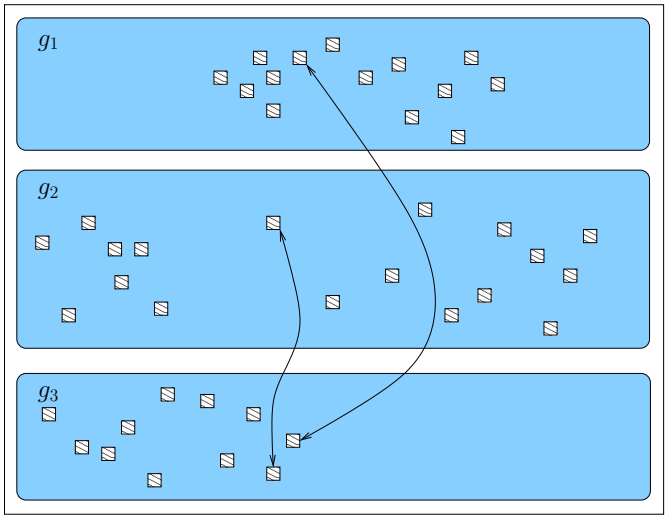
Solution Process of SGPlan on the AIRPORT-4 Instance



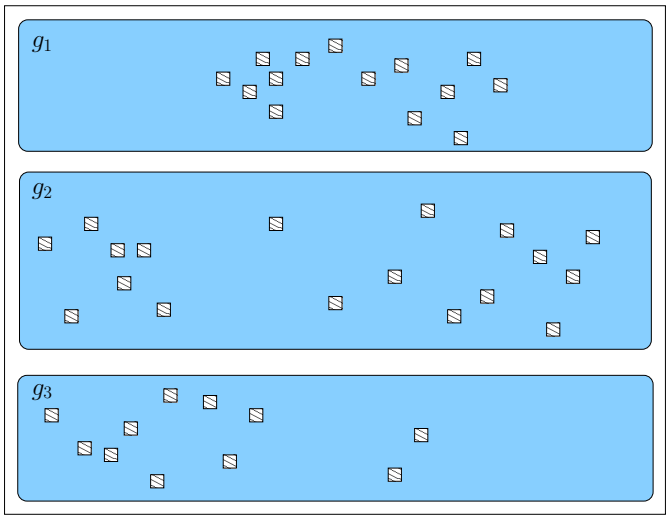
a) At the start of Iteration 2



b) After solving Subgoal g_1



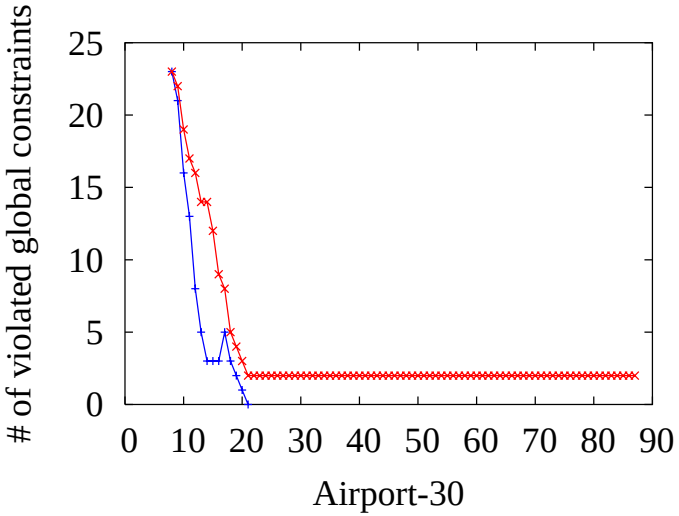
c) After solving Subgoal g_2

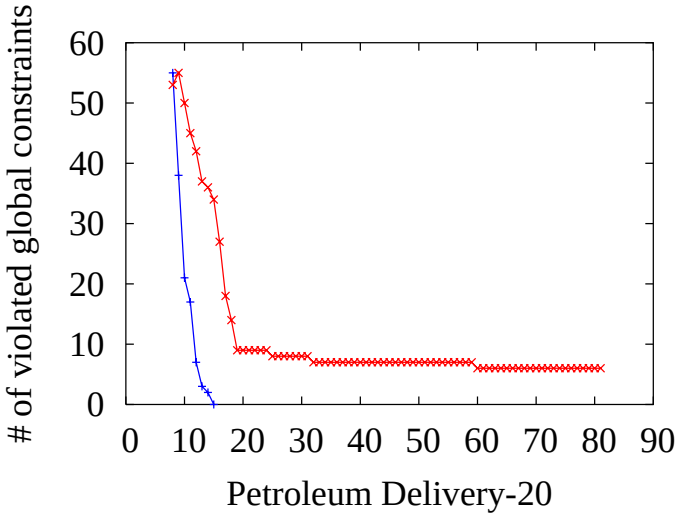


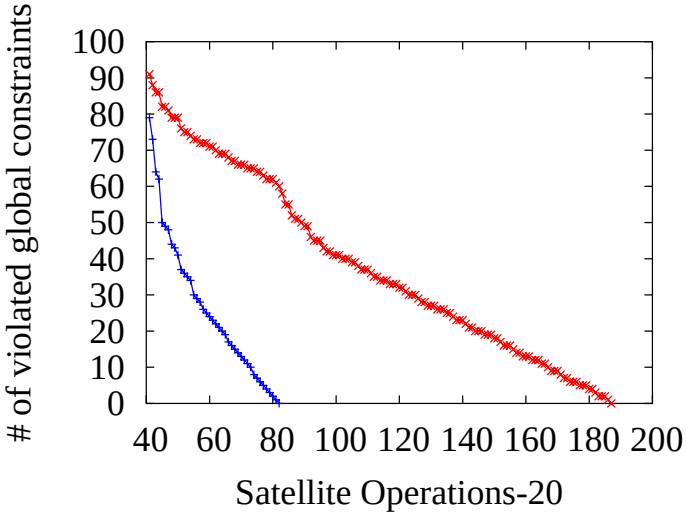
d) After solving Subgoal g_3

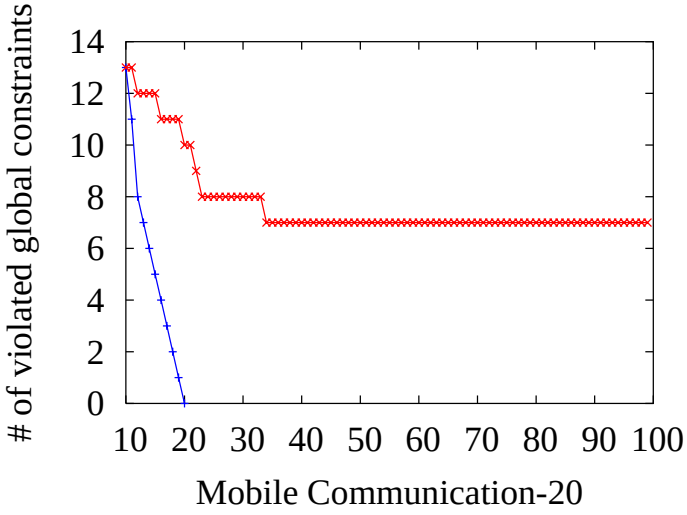
Reduction of Number of Violated Global Constraints

SGPlan using ESPC vs. Greedy search without ESPC









A Comparison of Six IPC4 Planners

Domain	Total	**SGPlan**	LPG	Downward	Macro-FF	YAHSP	Crikey
Airport	200	**155**	134	50	21	36	64
Pipesworld	260	**166**	113	60	62	93	111
Promela	272	**167**	83	83	38	42	13
PSR	200	**122**	99	131	32	48	29
Satellite	288	**207**	157	36	36	-	-
Settlers	20	**19**	13	-	-	-	-
UMTS	300	**274**	200	-	-	-	-
Overall	1540	**1110**	799	360	189	219	217

- SGPlan was the only planner that won in two tracks
  - First prize, Suboptimal Temporal Metric Track
  - Second prize, Suboptimal Propositional Track
  - Did not participate in the Optimal Track