

POEM[®]

Programming in Operational and Expressive Models

Management and Optimization

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ENGINEST

delivering intelligence

Step by Step ... to Success

- Foundation: June 2000, Spin-off from INRIA
- Profile: Planning and Scheduling Specialist
- Founders: 3 PhD brothers
- Offices: Nancy and Beijing
- Technology: NCL (Natural Constraint Language)
- Products: POEM[®], PlanSuite[™], POEM APS
- Market: Management & Optimization
- Strategy: A Product, Simpler and Smarter



- Mathematical Description Language
- Modeling and Solving



The NCL Natural Constraint Language

$$\begin{aligned} T_{i1} \in [150.0, 240.0], & \quad T_{o1} \in [250.0, 490.0], & \quad T_{i2} \in [150.0, 190.0], \\ T_{o2} \in [210.0, 340.0], & \quad FE1 \in [2.941, 10.0], & \quad FE2 \in [3.158, 10.0], \end{aligned}$$

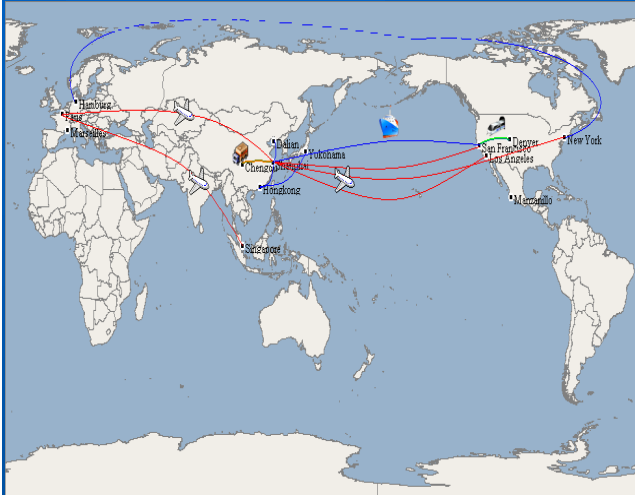
$$F_{i1} \geq 0.0, F_{i2} \geq 0.0, \quad FB12 \geq 0.0, FB21 \geq 0.0, \quad F_{o1} \geq 0.0, F_{o2} \geq 0.0,$$

$$\begin{aligned} T_{11} = 500.0 - T_{o1}, & \quad T_{12} = 250.0 - T_{i1}, & \quad T_{21} = 350.0 - T_{o2}, & \quad T_{22} = 200.0 - T_{i2}, \\ F_{i1} + F_{i2} = 10.0, & \quad F_{o2} + FB12 = FE2, & \quad F_{o1} + FB21 = FE1, & \quad F_{i1} + FB12 = FE1, \\ F_{i2} + FB21 = FE2, & & & \end{aligned}$$

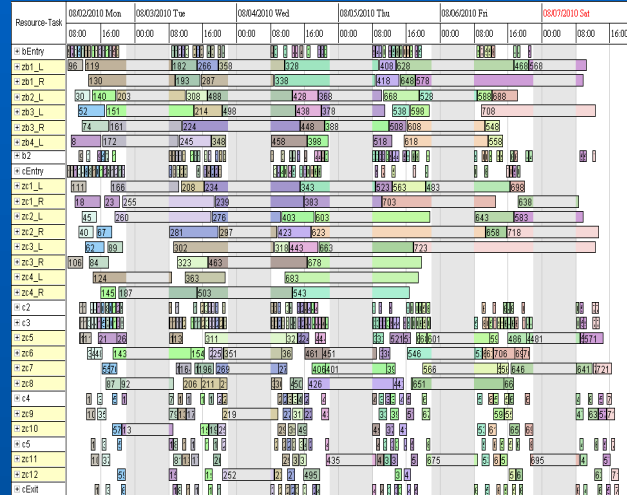
$$\begin{aligned} FE2 \times (T_{o2} - T_{i2}) = 600.0, & \quad FE1 \times (T_{o1} - T_{i1}) = 1000.0, \\ 150.0 \times F_{i1} + T_{o2} \times FB12 - T_{i1} \times FE1 = 0.0, & \quad 150.0 \times F_{i2} + T_{o1} \times FB21 - T_{i2} \times FE2 = 0.0, \end{aligned}$$

$$\begin{aligned} \min & \quad 1300 \times \exp(0.6 \times \log(20000 \times 6 / (4 \times \sqrt{T_{11} \times T_{12}} + (T_{11} + T_{12})))) + \\ & \quad 1300 \times \exp(0.6 \times \log(12000 \times 6 / (4 \times \sqrt{T_{21} \times T_{22}} + (T_{21} + T_{22})))) . \end{aligned}$$

Map



Gantt chart

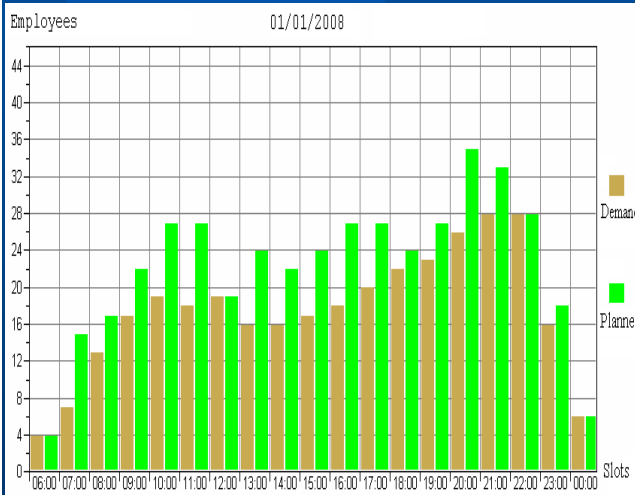


Table

派工计划表

订单编号	产品编号	时间安排	计划完成时间	延期(天)	
1	07060003	PART23	2007-08-06 11:34 - 2007-08-09 22:01	2007-08-10 09:11	否
2	07060007	PART1	2007-08-06 08:00 - 2007-08-07 09:55	2007-08-07 08:30	否
3	07060010	PART28	2007-08-07 19:36 - 2007-08-23 17:32	2007-08-24 00:27	否
4	07060013	PART16	2007-08-06 08:00 - 2007-08-22 08:00	2007-08-29 02:42	否
5	07060023	PART5	2007-08-06 08:00 - 2007-08-08 18:10	2007-08-10 20:30	否
6	07060025	PART29	2007-08-22 08:01 - 2007-09-26 08:33	2007-09-29 17:03	否
7	07060027	PART22	2007-08-06 08:00 - 2007-08-07 12:21	2007-08-08 02:03	否
8	07060036	PART3	2007-08-06 08:00 - 2007-08-21 10:40	2007-08-27 02:40	否
9	07060043	PART20	2007-08-06 09:01 - 2007-08-07 22:33	2007-08-08 04:41	否
10	07060044	PART21	2007-08-06 08:00 - 2007-08-06 23:31	2007-08-07 18:11	否
11	07060046	PART41	2007-08-23 14:33 - 2007-09-06 19:44	2007-09-11 13:57	否
12	07060065	PART12	2007-08-17 17:11 - 2007-08-30 10:01	2007-09-02 05:30	否
13	07060073	PART15	2007-08-06 08:00 - 2007-10-03 21:06	2007-11-07 16:30	否
14	07060080	PART10	2007-08-07 09:56 - 2007-08-23 19:30	2007-08-26 03:00	否

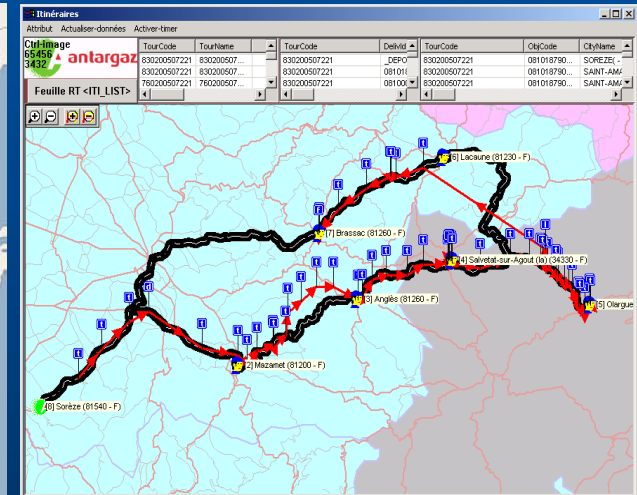
Histogram



Process simulation



Interaction



Linear Programming (Canonical Form)

$$\begin{array}{ll} \text{maximize} & c^T x \\ \text{subject to} & Ax \leq b \\ \text{and} & x \geq 0 \end{array}$$

Efficient

Numeric

Linear Model

Not The Only Choice

Programming in First-Order Logic Example: Crew Scheduling

$$\begin{array}{l} \text{Pairing} \quad \text{PAIRING}, \\ \bigcup_{i \in \text{Pairing}} \text{LegPairing}_i = \text{LEG}, \\ \min \sum_{i \in \text{Pairing}} \text{costPairing}_i \end{array}$$

Quantifier Logic

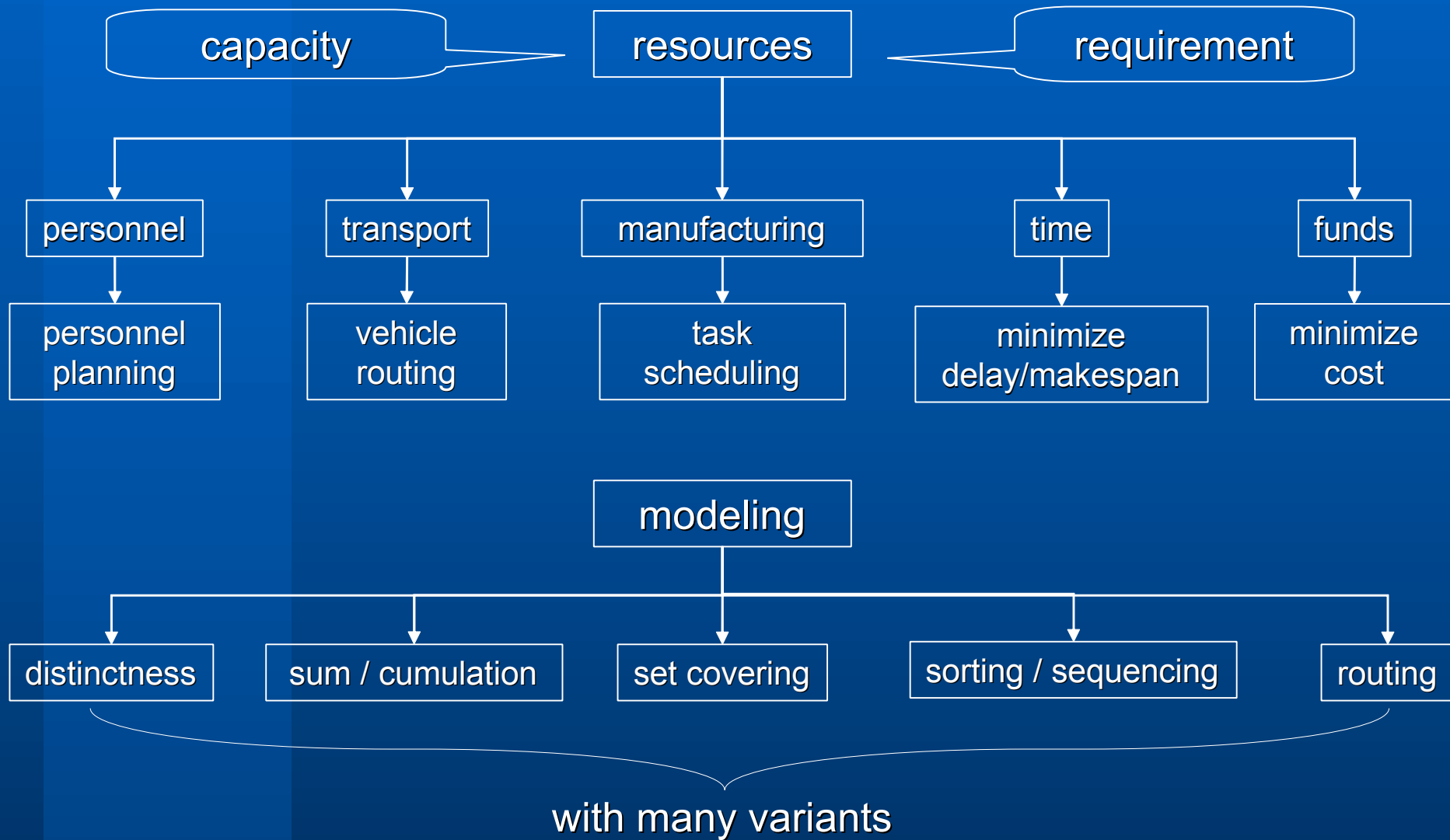
Set Programming

Logical Function

Object Oriented

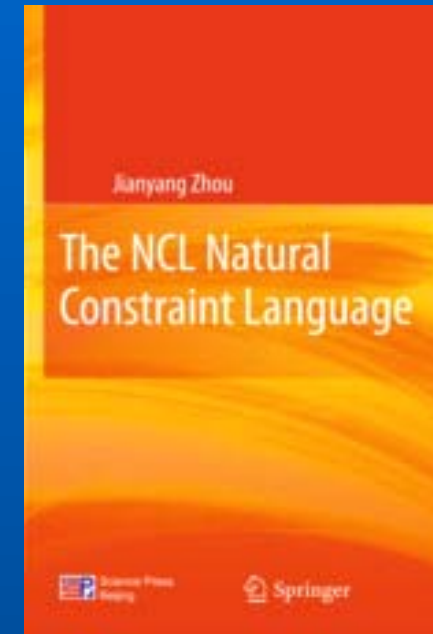
Can Be The Best

Resource Optimization



Books

- J. Zhou: The NCL Natural Constraint Language. Springer, ISBN 978-3-642-23844-4 (2012).
- J. Zhou: The NCL Natural Constraint Language. Science Press Beijing, ISBN 978-7-03-031784-1 (2012).
- 周建阳: 《自然约束语言》. 科学出版社, ISBN 978-7-03-024973-9 (2009).



Journal Papers

- J. Zhou: Introduction to the constraint language NCL. Journal of Logic Programming. 45 (1-3): 71-103 (2000).
- J. Zhou: A Permutation-Based Approach for Solving the Job-Shop Problem. Constraints 2(2): 185-213 (1997).



The POEM Platform

Simpler • Smarter • Swifter

```
89 % Cumulative Scheduling
90
91 \forall i <> j \in TASKCRUCIALRESOURCE
92   TimeTask_{i} \cap TimeTask_{j} =
93
94
95 % Set Partitioning for Tasks on Resources
96
97 ACTIVERESOURCE \subset RESOURCE,
98
99 ACTIVETYPESOURCE = \{ \forall i \in ACT:
100
101
102 \forall i \in RESOURCE {
103   TaskResource_{i} \subset TASK,
104
```

C2: ' delay ' decreased to 416
depth:258-258 solution(s):6 time:117.338000 backtrack(s):479 rotation(s):6303
break at solution
Warning C22: optimization step ' stepObj1 ' (= 600) may be too large
depth:21-258 solution(s):6 time:167.440000 backtrack(s):717 rotation(s):7488
C2: ' delay ' decreased to 0

Debug Timer Trace level 1 Execute Find Info Warning Suggestion Memo

Ready Ln 17, Col 1 Running time 188.170 Depth



Logic + Optimization + Heuristic Rules + View

Integration

- PoemServer: Application Server
- ComPoem: Optimization Component
- PoemView: Visualization Component

NCL

- Mathematical Description Language
- Modeling, Solving, Optimization

PoemView

- Visualization: Gantt chart, Map, etc.
- What If Interaction

File	Folder	#Visit	Last visit	Command	URL	Message	Host
OrderPlanG...	C:\Program Files\ENG...	2	07/30/12 10:...		/MMTP/OrderPlanGantt.view		127.0.0...
GlobalMap...	C:\Program Files\ENG...	1	07/30/12 10:...		/MMTP/GlobalMap.view		127.0.0...
Schedule.vi...	C:\Program Files\ENG...	2	07/30/12 09:...		/VRP/Schedule.view		127.0.0...
Map.view	C:\Program Files\ENG...	1	07/30/12 09:...		/VRP/Map.view		127.0.0...

Client name	Client IP	Request time	Start time	End time	Server IP	Status	Detail	Reference	Program fi
127.0.0.1	127.0.0.1	07/30/12 08:...	07/30/12 08:...	07/30/12 08:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 08:...	07/30/12 08:...	07/30/12 08:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 08:...	07/30/12 08:...	07/30/12 08:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 08:...	07/30/12 08:...	07/30/12 08:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 09:...	07/30/12 09:...	07/30/12 09:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 09:...	07/30/12 09:...	07/30/12 09:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 09:...	07/30/12 09:...	07/30/12 09:...		Success		NCL_ENGINES...	C:\Program...
127.0.0.1	127.0.0.1	07/30/12 09:...	07/30/12 09:...	07/30/12 09:...		Success		NCL_ENGINES...	C:\Program...

Uptime: 08h 18m



Applications

- Logistics
- Manufacturing
- Airline Companies
- Human Resources
- High-Speed Trains...

Licensing

- Application license: for end-users and software integrators
- Development license: for software developers
- Academic license: for universities and institutes

Optimizing depots location and distribution of dangerous materials: gas, fuel, ...

The screenshot displays the PlanSuite software interface for distribution planning. The main window shows a map of France with numerous colored markers representing depots and their service areas. A detailed view of a specific route is shown on the right, with a table of stops and a data table at the bottom.

ITINÉRAIRES

Attribut	Actualiser-données	Activer-timer	TourCode	Delivid	TourCode
Ctrl-image					
65456	antargaz		830200507221	830200507...	830200507221
3432			830200507221	830200507...	830200507221
			760200507221	760200507...	760200507221
			830200507221	830200507...	830200507221

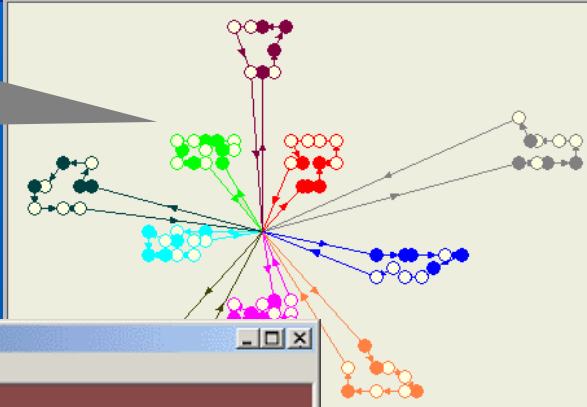
Feuille RT <ITI_LIST>

Ord	Or...	N°Com...	N...	Etat	Fi...	A...	R...	Q...	D...	Ville	Heure...	KM	Te...	Tonn...	Litrag	Jau...	Code client
P		Départ	Ap...	Validée						Quéven Parking [...]	07:30	0	0	7332	14664	100	031201009
1	1	0078748		Validée						Saint-Caradec-T...	08:34	38.1	1H04	1400	2800	15	G5600254...
2	2	0069309		Validée		SMS	SM...			Cléguérec (5648...	09:47	30.0	0H53	2782	5564	13	G5600543...
3	3	0078039		Validée						Pluméliau (5693...	11:01	24.1	0H44	3150	6300	0	G5600241...
C		Charge...	VR03							Quéven PDR (50...	12:57	45.7	1H23				287
P		Retour								Quéven Parking [...]	13:46	2.6	0H04				

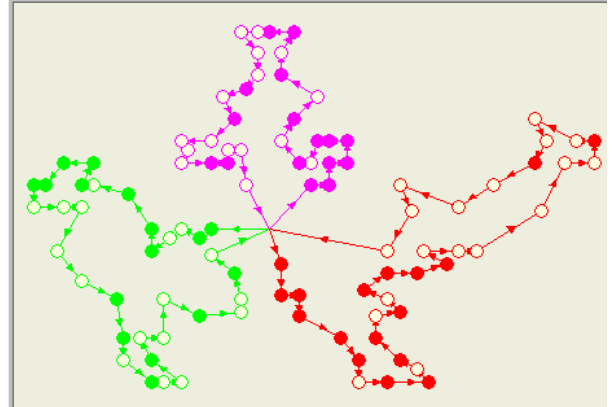
Vehicle Routing (Benchmarking)

Simpler • Smarter • Swifter

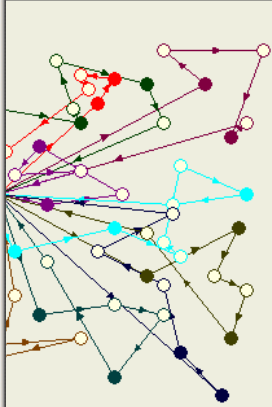
Optimal Solution
to Solomon Problems



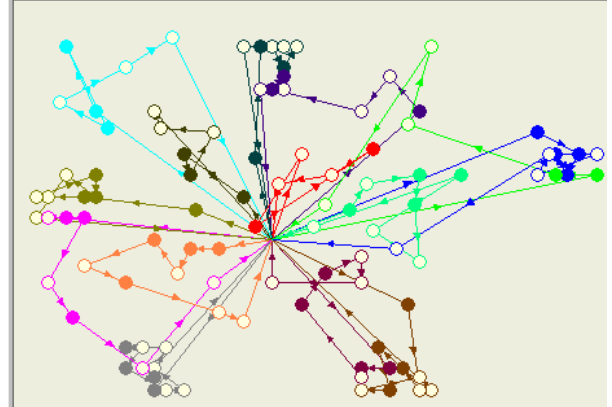
106 cost: 829



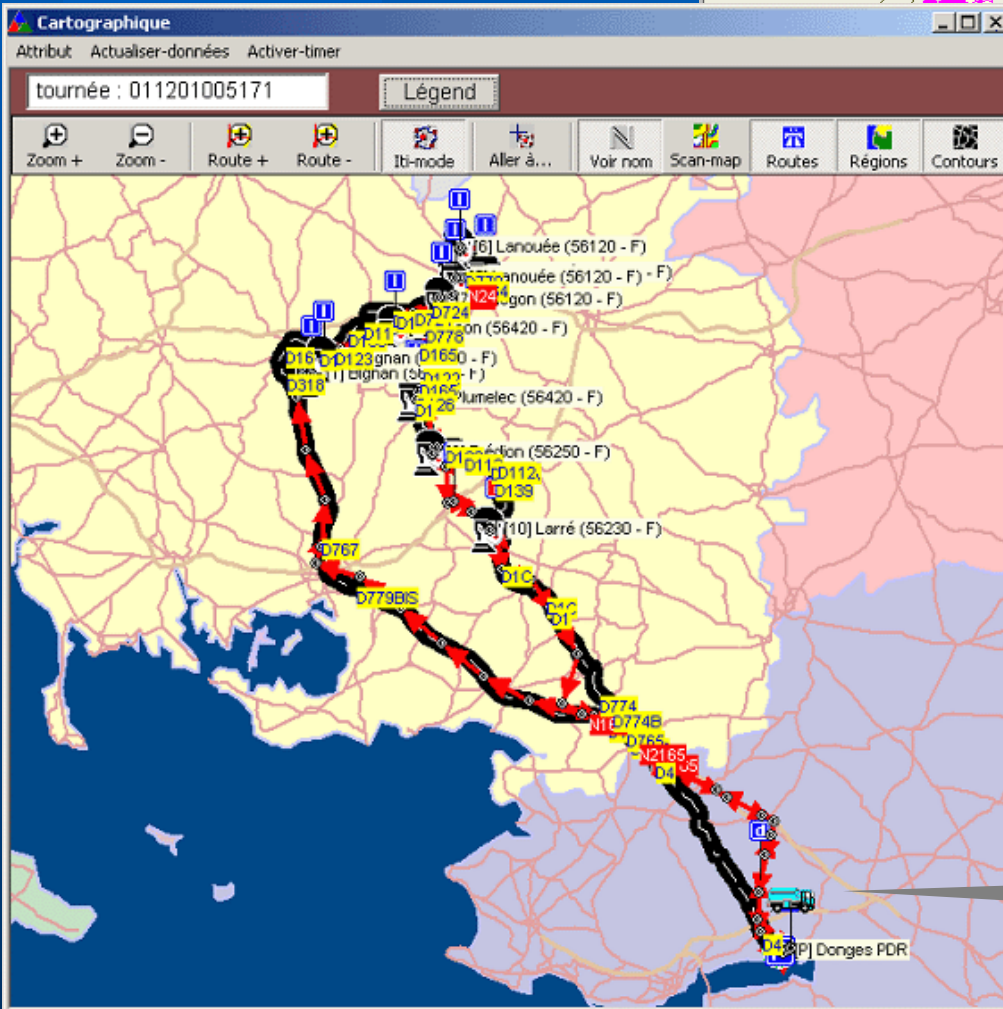
#Truck: 3 #Client: 102 cost: 590



106 cost: 1638



#Truck: 14 #Client: 106 cost: 1702

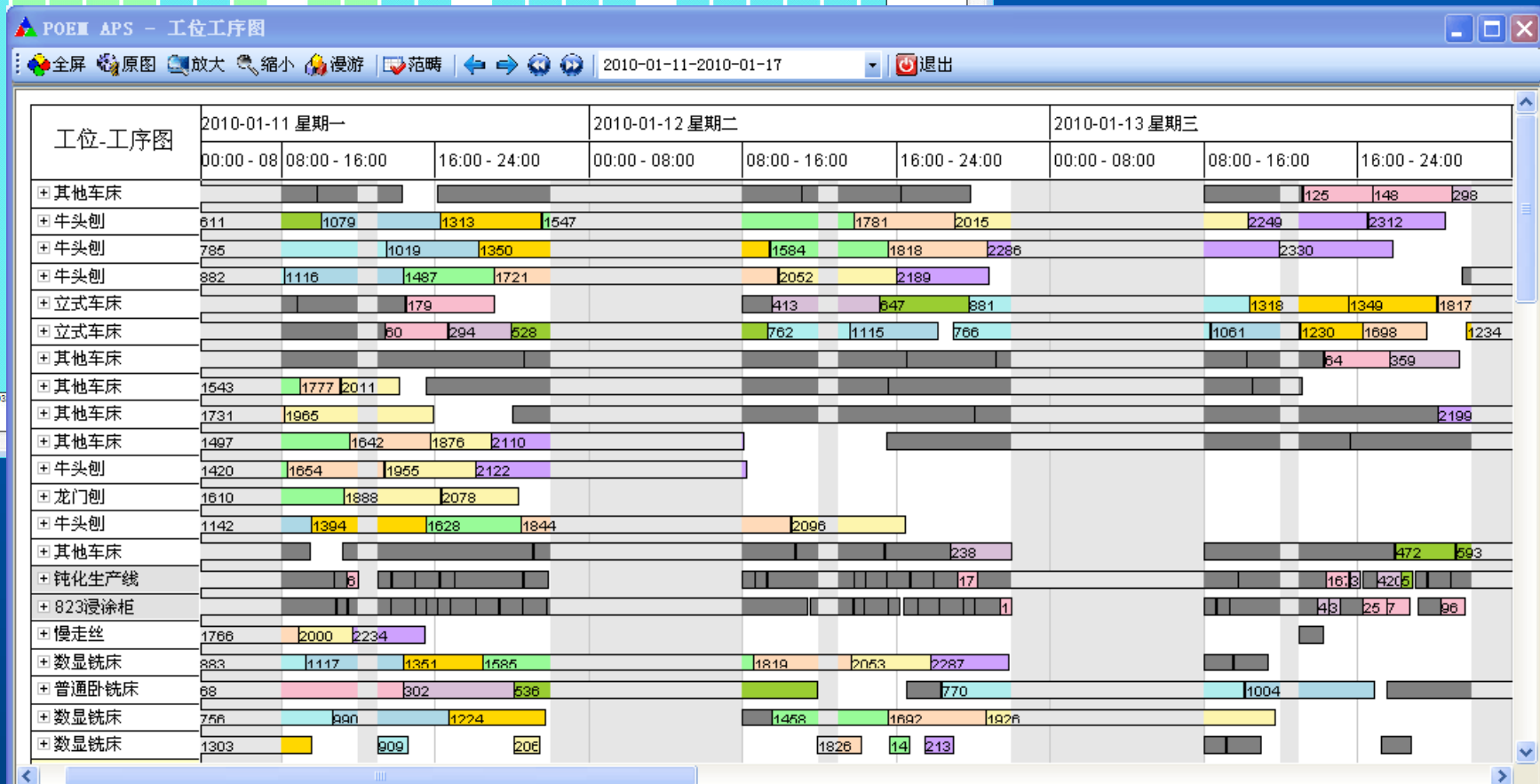
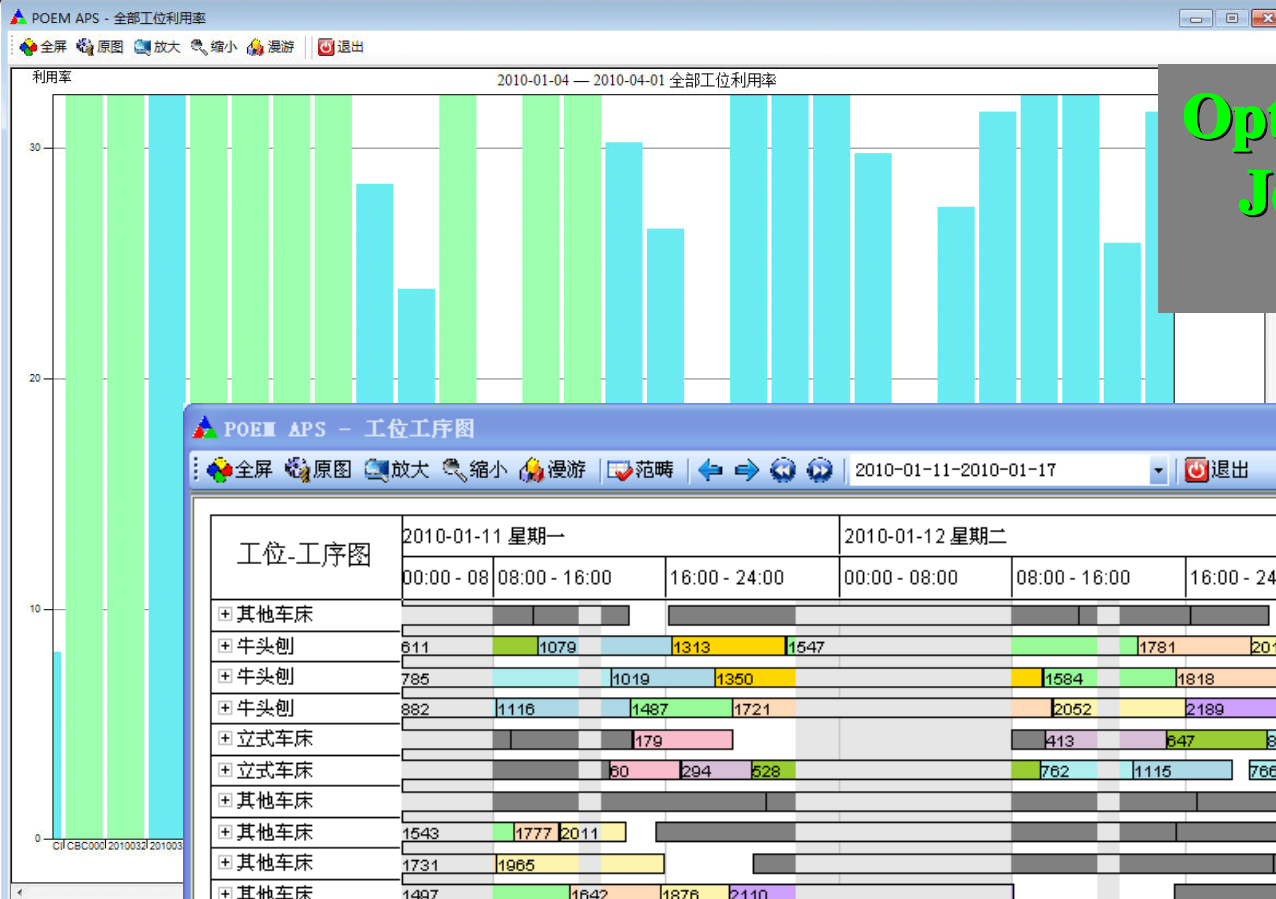


In Reality

POEM APS: Production Scheduling

Simpler • Smarter • Swifter

Optimization Module for
Job/Task Scheduling
over Resources.



Production Scheduling: Electronics

Simpler • Smarter • Swifter

Scheduling jobs on resources so as to efficiently make products.

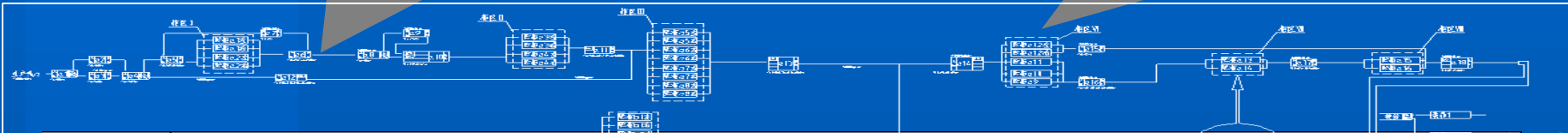


工位-工序图	2010-01-04 星期一			2010-01-05 星期二			2010-01-06 星期三			2010-01-07 星期四			2010-01-08 星期五			
	00:00 - 08:00	08:00 - 16:00	16:00 - 24:00	00:00 - 08:00	08:00 - 16:00	16:00 - 24:00	00:00 - 08:00	08:00 - 16:00	16:00 - 24:00	00:00 - 08:00	08:00 - 16:00	16:00 - 24:00	00:00 - 08:00	08:00 - 16:00	16:00 - 24:00	
+ 其他车床	158 416				390	82				582 674 932				1098	942	
+ 牛头刨	151	409			667	925		1183	1441					2215	2473	
+ 牛头刨	813 618 111 111 2150				2											
+ 牛头刨	19 45 71 97 12 14 1744				20 22 25											
+ 立式车床	195	66			453	426			711			969	840	1227	617	
+ 立式车床	62 320	168				578		29 836	1094			1352 1610 1868		684		
+ 其他车床	96	354			612			870	1128			1386		1644	1902	
+ 其他车床	36 294 552 810				1066 1326 1584			184 210 2358								
+ 数控	1 2 7 11 16 1 143				215	2 3 3 2 271		4 3 4 4 01	473			6 4 4 5 5 6 5 6 6 59		731	7 8 828	
+ 牛头刨	1 2 7 5 7 9 1 1 1 564				1 8 2 2 3											
+ 钝化生产线	6 1 1 2 4 4 4 6 6				4 6 2 3 6 5 9 9 6 39			6 9 2 1 1 2 5 3				1 1 1 2 7 1 2 6 0 3		1 1 1 3 1 1 6 6 1		
+ 镀金生产线	1 5 1 3 3 3 6 5 9				7 4 4 4 7 9 4 4 8			2 7 7 8 9 9 9 1 7				3 5 1 1 1 1 1 1 1 1		3 1 1 4 6 8 6 1 4 1 7		
+ 823浸涂柜	1 5 0 1 1 3 4 1 3 2 1 80				4 6 6 2 8 3 6 6 4 1 1 7			7 5 6 2 7 3 8 9 9 1 7				2 2 9 4 4 9 8 1 1 1 8 7		3 4 5 6 8 9 1		
+ 慢走丝	1 3 5 3 9 3 6 5 1 4 6				9 0 9 1 1 6 1 4 2 1 6 8 3			1 9 4 2 1 9 3 2 4 5						5		
+ 数显铣床	2 2 4 8 7 4 1 0 1 2 1 5 1 9				1 7 2 0 2 2 2 5						2 7			1 7 3		
+ 普通卧铣床	1 9 7 4 5 5 7 1 3 9 7 1				1 2 2 1 4 8 1 7 4 2 0 0 3			2 2 6 2 5 1 1								
+ 数显铣床	7 0 3 2 8 5 8 6 8 4 4				1 1 0 1 3 6 0 1 6 1 1 8 7 6			2 1 3 4 2 3 9 1								
+ 卧式镗	5 5 3 1 3 5 7 1 8 2 9				1 0 8 1 3 4 8 1 6 0 1 8 6 1			2 1 1 4 2 3 7 1								
+ 漏印	9 8 6															
+ 钳	9 1 6 9 4 3 1 1 3 1 3 4 1 0 1 7				3 1 7 1 1 1 1 1 1 1 1 1 4 0 3			2 1 1 1 1 1 1 1 1 1 1 1 5 3				1 1 8 1 1 1 1 1 2 1 1 2 0 8 6		2 1 1 1 1 1 1 1 1 1 1 1 2 4 9 4		
+ 数冲	9															
+ 数铣	9 8 7 1 7 4 1 6 8 9 4 5				1 4 6 1 1 8 1 8 2 2 2 1 3 9 6			5 1 2 1 4 1 6 0 1 1 1 1 1 8 6 4				2 5 1 6 1 2 8 1 8 1 8 5 3 1		1 6 1 2 1 1 6 0 1 1 2 4 2 8		
+ 涂	9 3 5															
+ 真空热处理	8 3 5 8 1 1 1 1 1 2 1 4 7				2											
+ 真空热处理	1 4 6 9 1 1 1 1 2 2 4 7 8															
+ 数车	1 1 5 3 7 3 6 3 1 8 8 9				1 1 4 1 4 0 1 6 6 1 9 2 1			2 1 7 2 4 3 1								
+ 数车	1 8 2 4 4 0 6 8 8 9 5 6				1 2 1 1 4 7 1 7 3 1 9 8 8			2 2 4 2 5 0 1								
+ 数车	1 5 3 4 1 1 6 6 9 9 2 7				1 1 8 1 4 4 1 7 0 1 9 5			2 2 1 2 4 7								
+ 数显铣床	3 0 2 9 5 4 3 0 1 6				1 3 1 4 1 8 2 0 2 3						3 3					
+ 数显铣床	3 4	3 6 8			6 8 1 1			1	4 3 1 2 7 2 2 4 1 9						5 3	
+ 组夹	7 5 6 6 4 3 5 8 4				9 5 8 3 1 2 3 5 1 4 8 1 6			7 7 4 1 7 5 4 1 3 1 1 1 3 5 8				1 6 1 1 2 1 2 3 9 1 4 1 5 2 9		2 0 6 6 1 1 2 2 5 8 0		
+ 数显铣床	2 1				4 4 1 4 6 5 3			9 6 1 2 1 4			6 6 1 4		1 9 4 3 2 2 0 1			
+ 龙门刨	1	4 8 5			7 4 3 1 0 0 1 1 2 5 9			1 5 1 7 1 7 7 5			2 0 3 3 2 2 9 1 2 5 4 9					
+ 水切割	1 2	1 6 1			7			3 8 3 7 3 1 9 3 3 1			6 2 6 2 8		5 7 7 5			
+ 数显铣床	4 4 7 2 1 7 9 7 8				1 1 1 4 0 0 2 2 8			2 1 1 6 5 8 1 9 1 6			2 1 7 4 6 9 2		2 4 3 2			
+ 其他车床	1 4 7 4 0 5				1 3 2 6 6 3 9 2 1 1 1 7 9			1 4 3			1 6 8 0 1 9 3 8		2 1 9 6 2 4 5 4			
+ 供漆系统	1				1			4	4		2 1 1 3 7		3 1 6 2			
+ 数钻	2 1 4 2 0 9				7 6 4 3 2 1 1 1 1			1 3 1 1 1 2 4 2 2 2 2 0 1 5			2 2 2 5					



Process Scheduling

Discrete Scheduling



Resource-Task	08/02/2010 Mon		08/03/2010 Tue		08/04/2010 Wed		08/05/2010 Thu		08/06/2010 Fri		08/07/2010 Sat			
	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00
+ bEntry	[Gantt chart bars]													
+ zb1_L	96	119	182	266	358	328	408	528	438	588	638	688	708	721
+ zb1_R	130		193	287	338	418	648	578						
+ zb2_L	30	140	203	308	488	428	388	668	528	588	688			
+ zb3_L	52	151	214	498	438	378	538	598						
+ zb3_R	74	161	224	448	388	508	608	548						
+ zb4_L	8	172	245	348	458	398	518	618	558					
+ b2	[Gantt chart bars]													
+ cEntry	[Gantt chart bars]													
+ zc1_L	111	166	208	234	343	523	563	483	698					
+ zc1_R	18	23	255	239	383	703	638							
+ zc2_L	45	260	276	403	603	643	583							
+ zc2_R	40	67	281	297	423	623	658	718						
+ zc3_L	62	89	302	318	443	663	723							
+ zc3_R	106	84	323	463	678									
+ zc4_L	124		363	683										
+ zc4_R	145		187	503	543									
+ c2	[Gantt chart bars]													
+ c3	[Gantt chart bars]													
+ zc5	11	21	26	113	311	32	22	44	33	52	15	66	60	1
+ zc6	34	44	143	154	425	351	36	461	451	33	546	518	670	647
+ zc7	54		7	116	196	269	27	406	401	39	566	451	646	641
+ zc8	87	92	206	211	2	33	45	426	44	651	66			
+ c4	[Gantt chart bars]													
+ zc9	10	35	75	13	17	219	23	31	2	4	3	3	5	6
+ zc10	57		13	14	19	24	23	34	49	4	3	4	53	67
+ c5	[Gantt chart bars]													
+ zc11	11	3	8	11	1	21	24	3	3	435	4	3	5	675
+ zc12	54		14	1	252	2	2	495	3	4	5	6	695	4
+ cExit	[Gantt chart bars]													

Personnel Planning: Call Center

Simpler • Smarter • Swifter

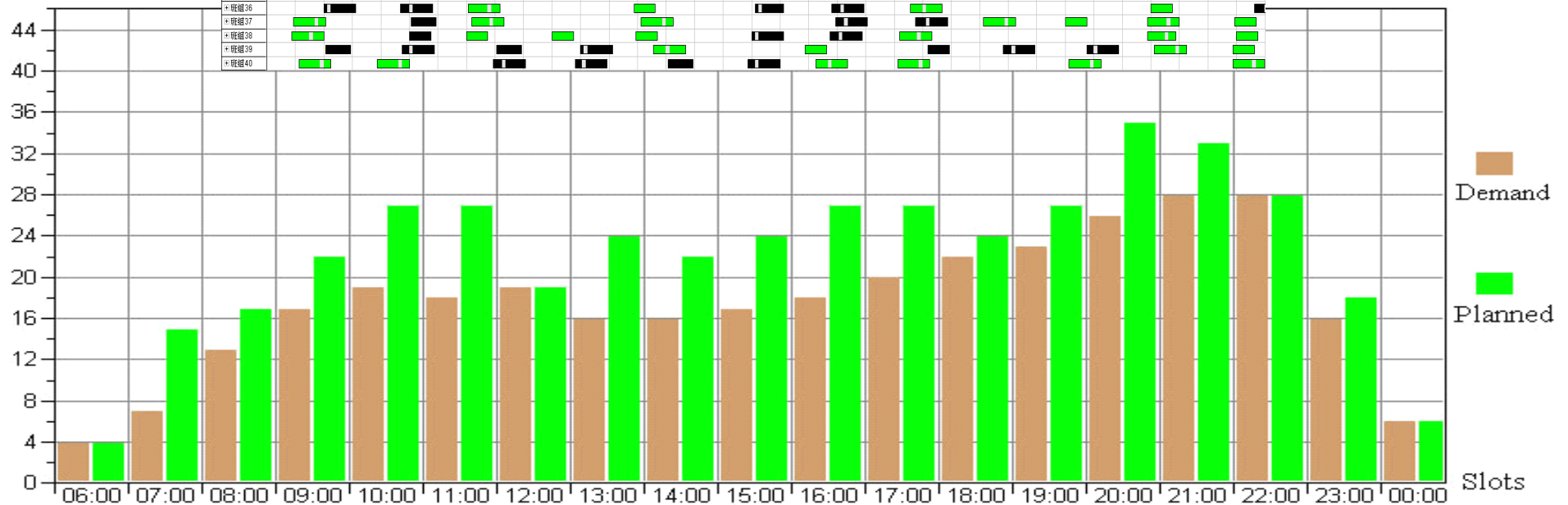
班组安排 甘特图	2008-08-01 星期五			2008-08-02 星期六			2008-08-03 星期日			2008-08-04 星期一			2008-08-05 星期二			2008-08-06 星期三			2008-08-07 星期四			2008-08-08 星期五			2008-08-09 星期六			2008-08-10 星期日			2008-08-11 星期一			2008-08-12 星期二		
	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00	00:00	08:00	16:00			
• 班组01																																				
• 班组02																																				
• 班组03																																				
• 班组04																																				
• 班组05																																				
• 班组06																																				

Planning a working schedule for the employees of a call center to satisfy personnel requirement.



• 班组26																																	
• 班组27																																	
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Employees



Thank you



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