Integrating Business Rules and Constraint Programming Technologies for EDM

Dr. Jacob Feldman, OpenRules, Inc., Chief Technology Officer,
jacobfeldman@openrules.com
j.feldman@4c.ucc.ie

Prof. Eugene Freuder, Cork Constraint Computation Centre, Director
e.freuder@4c.ucc.ie

Outline

- Business Optimization and Constraint Programming (CP)
- Real-world examples
- BR + CP integration scenarios
- How different CP solvers can be incorporated into different BR products: CP-Inside
- Online decision support with Business Rules, Constraints, and Machine Learning

Business Optimization

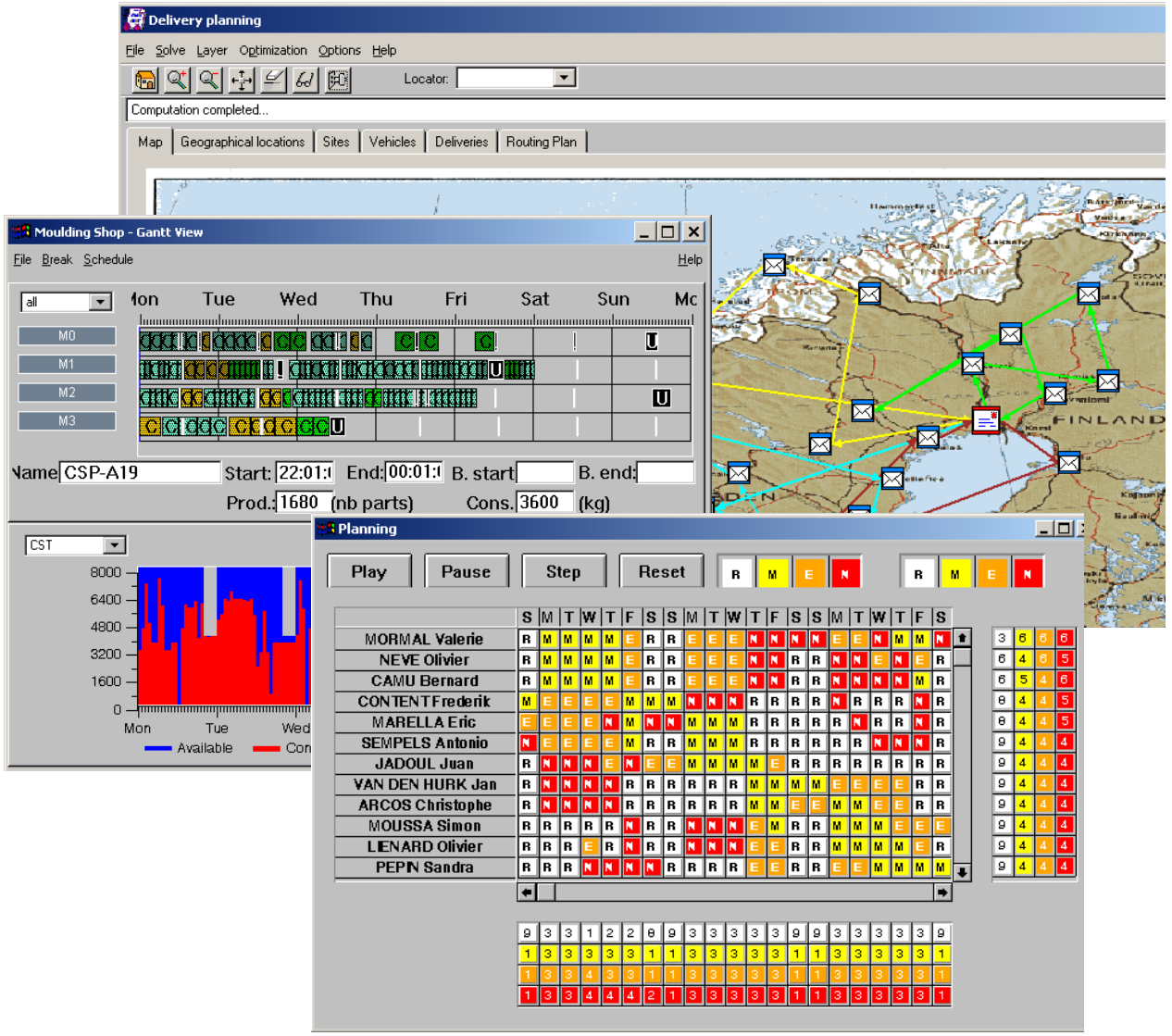
- **Optimization usually refers to a mathematical technique used to calculate the *best* possible resource utilization to achieve a desired optimization objective such as:**
  - minimizing expenses or travel time
  - maximizing ROI or service level, etc.
- **Business Optimization helps *business* people to find optimal solutions among multiple alternatives subject to different *business* constraints**
- **Optimization Engine:**
  - Determines how to most effectively allocate resources, automatically balancing trade-offs and business constraints
  - Eliminates the need to manually work out plans and schedules, so you can achieve maximum operational efficiency

Constraint Programming: a bridge between academy and business

- **Constraint Programming (CP) is a proven optimization technology that is the most friendly to corporate developers**
- **During the 90s CP successfully built a bridge between the academic and business worlds by providing an API for the mainstream programming languages**
- **Constraints arise in design and configuration, planning and scheduling, diagnosis and testing, and in many other contexts**
- **CP was successfully applied to solve real-world problems in:**
  - telecommunications, internet commerce, electronics, bioinformatics, transportation, network management, supply chain management, finance, manufacturing, and many other fields

Typical CP Applications

- Scheduling and Resource Allocation
- Complex Configuration Problems
- Supply Chain Management
- Staff Rostering
- Vehicle Routing



CP and Optimization are back

- **In recent years CP was suppressed by BR**
- **Nowadays CP and Optimization technology in general is quickly becoming a "must-have" component of the EDM – Enterprise Decision Management**
- **Both BR leaders ILOG and Fair Isaac put Optimization among key components of their EDM vision:**
  - ILOG has for a long time the best optimization tools including famous ILOG CPLEX and CP Optimizer
  - Fair Isaac recently acquired and incorporated Xpress-MP in their product offerings
- **Many open source optimization products also achieved a competitive level and are ready for the prime time**
- **Incorporating CP into Business Rules Management systems empowers a BRMS with much more sophisticated decision-support capabilities**

When CP does well

- **CP does well when BR stops short :**
  - Number of alternatives goes beyond thousands and millions
  - Close to optimal decisions are expected in real time
  - Compromise between time and quality is required
- **Powerful and affordable CP tools are available now:**
  - Open source CP Solvers
  - A choice of commercial CP Solvers
  - Friendly APIs for mainstream programming languages

Constraints and Rules are similar

- **Both rules and constraints represent conditions which restrict our freedom of decision:**
  - The meeting must start no later than 3:30PM
  - Glass components cannot be placed in the same bin with copper components
  - The job requires Joe or Jim but cannot use John
  - Bob prefers not to work on weekends
  - The portfolio cannot include more than 15% of technology stocks unless it includes at least 7% of utility stocks
- **Both rules and constraints support declarative programming**
  - Concentrate on WHAT instead of HOW
  - The same basic idea:
    - a user states the Rules (or Constraints)
    - a general purpose Rule Engine (or Constraint Solver) solves them

Constraints and Rules are different

- **BR Advantage:**
  - Rules Repository is managed by business people while Constraints are usually under control of software developers
- **CP Advantage:**
  - Rules usually should consider all (!) possible combinations of the problem parameters
  - Constraints do not have to cover all situations but rather define an optimization objective and allow a search algorithm to find the optimal solution
- **BR+CP provides the best of both worlds:**
  - BR defines an optimization problem, CP solves it

Rules and Constraints Working Together

Financial Portfolio Management

- Business rules such as "*Technology Stocks should be within 15% and 20%*" define the target portfolio
- Rule Engine warns about possible rule violations during sell/buy
- Business Objective:
  - Keep all portfolios as close as possible to the target portfolio
- Constraint Solver recommends the best combination of trade orders to minimize the total rules violation

Rules and Constraints Working Together

Loan Origination

- A borrower provides a desired loan purpose, amount, term along with personal data
- Rule Engine executes complex eligibility rules to define all available loan products for this borrower
- Business Objectives:
  - avoid loan rejections or lengthy “what-iffing”
  - allows *“reasonable violations”* of the requested loan parameters while recommending a loan with a minimal interest rate
- Constraint Engine recommends the best combination of the loan amount, term, and product characteristics to select the most suitable loan product

Rules and Constraints Working Together

Telecom Service Configuration

- Personalized configuration of available calling plans and other wireless, local, long distance, and Internet services
- Rule Engine determines cross/up selling opportunities and specifies different marketing campaigns
- Business Objective:
  - Customer retention
  - Using a customer's preferences and an actual calling pattern recommend the best set of services while a CSR is on the phone with a complaining customer
- Rule and Constraint Engines work together with customer data to determine and deliver the best account management advice

Rules and Constraints Working Together

Insurance Pricing Discount Calculation

- According to the specified business rules, the customer is eligible to N different discounts
- There is a rule/constraint that states that the total discount cannot be more than x%
- Business Objective:

  find a combination of the discounts that satisfies the “x%” constraint while maximizing/minimizing the premium
- Rule engine figures out all eligible discounts
- Optimization engine finds the best alternative for customer and for the insurance company

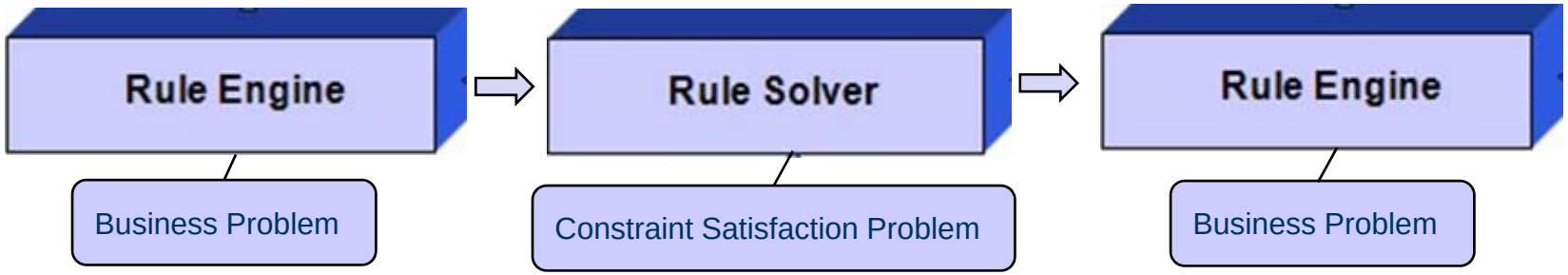
Rules and Constraints Working Together

Field Service Scheduling a public utility company

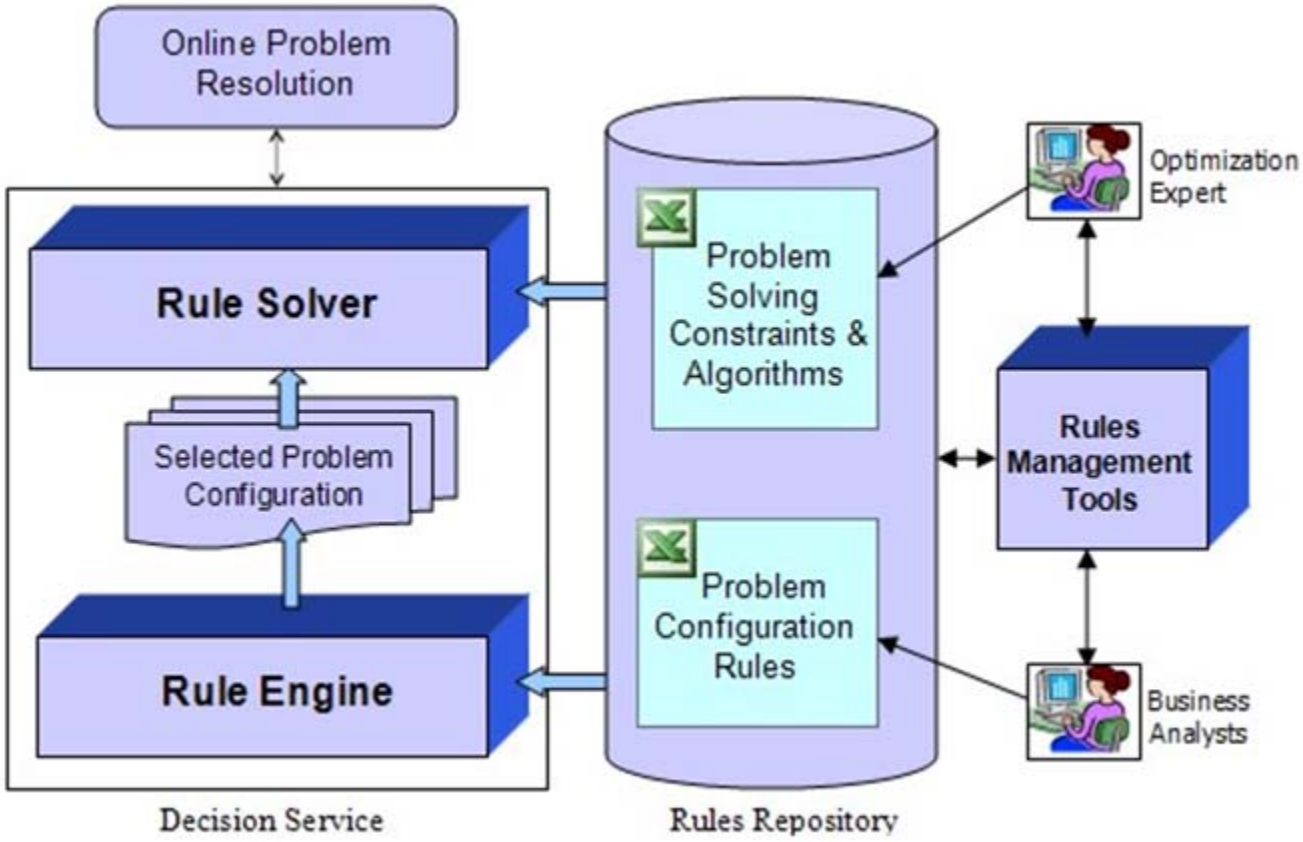
- Typical problem:
  - more than a million customers
  - several thousands employees with different skills and equipment
  - large service territory
  - hundreds or thousand small and large jobs per day
  - each job requires a mix of people skills, vehicles and equipment
- Conflicting Business Objectives:
  - Minimize travel time , level resource load, use the least costly skills/equipment, schedule jobs ASAP, honor employee preferences
- Rule Engine configures preferences and relative objectives for different constraint satisfaction problems
- Constraint Solver does on-demand scheduling and resource allocation

BR+CP Integration

- Business rules could be used to define and modify a business objects
- Rule Engine can generate a related constraint satisfaction problem representing it in terms of constrained objects and constraints
- CP Solver can solve the optimization problems and return the results to the Rules Engine for further analysis



BR + CP Integration Schema



Example: Sudoku with Rules & Constraints

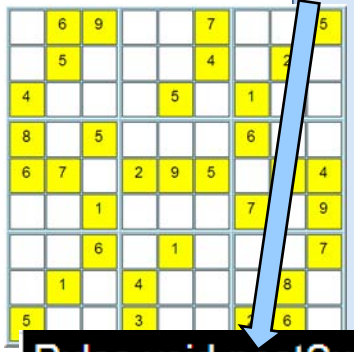
	6	9			7			5
	5				4		2	
4				5		1		
8		5				6		
6	7		2	9	5		1	4
		1				7		9
		6		1				7
	1		4				8	
5			3			2	6	

1	6	9	8	2	7	3	4	5
7	5	8	1	3	4	9	2	6
4	3	2	9	5	6	1	7	8
8	9	5	7	4	1	6	3	2
6	7	3	2	9	5	8	1	4
2	4	1	6	8	3	7	5	9
3	2	6	5	1	8	4	9	7
9	1	7	4	6	2	5	8	3
5	8	4	3	7	9	2	6	1

Rules vs. Constraints:

- **You may use rules to represent and solve the Sudoku problem. But you will end up with many very technical and hard to understand rules**
- **OR you may incorporate the predefined constraint "*AllDifferent* " into a simple decision table** (next slide)

Sudoku Constraints in Excel Rules Table



Rules void postSudokuConstraints(CpProblem p)											
Array Name	**Variables**										
row0	x00	x01	x02	x03	x04	x05	x06	x07	x08		Row Constraints
row1	x10	x11	x12	x13	x14	x15	x16	x17	x18		
row2	x20	x21	x22	x23	x24	x25	x26	x27	x28		
row3	x30	x31	x32	x33	x34	x35	x36	x37	x38		
row4	x40	x41	x42	x43	x44	x45	x46	x47	x48		
row5	x50	x51	x52	x53	x54	x55	x56	x57	x58		
row6	x60	x61	x62	x63	x64	x65	x66	x67	x68		
row7	x70	x71	x72	x73	x74	x75	x76	x77	x78		
block01	x03	x04	x05	x13	x14	x15	x23	x24	x25		Block Constraints
block02	x06	x07	x08	x16	x17	x18	x26	x27	x28		
block10	x30	x31	x32	x40	x41	x42	x50	x51	x52		
block11	x33	x34	x35	x43	x44	x45	x53	x54	x55		
block12	x36	x37	x38	x46	x47	x48	x56	x57	x58		
block20	x60	x61	x62	x70	x71	x72	x80	x81	x82		
block21	x63	x64	x65	x73	x74	x75	x83	x84	x85		
block22	x66	x67	x68	x76	x77	x78	x86	x87	x88		

Rules void postSudokuConstraints(CpProblem p)

Action

```
CpVariable[] array = p.addArray(name,vars);
p.allDiff(array).post();
```

String name	String[] vars
Array Name	**Variables**

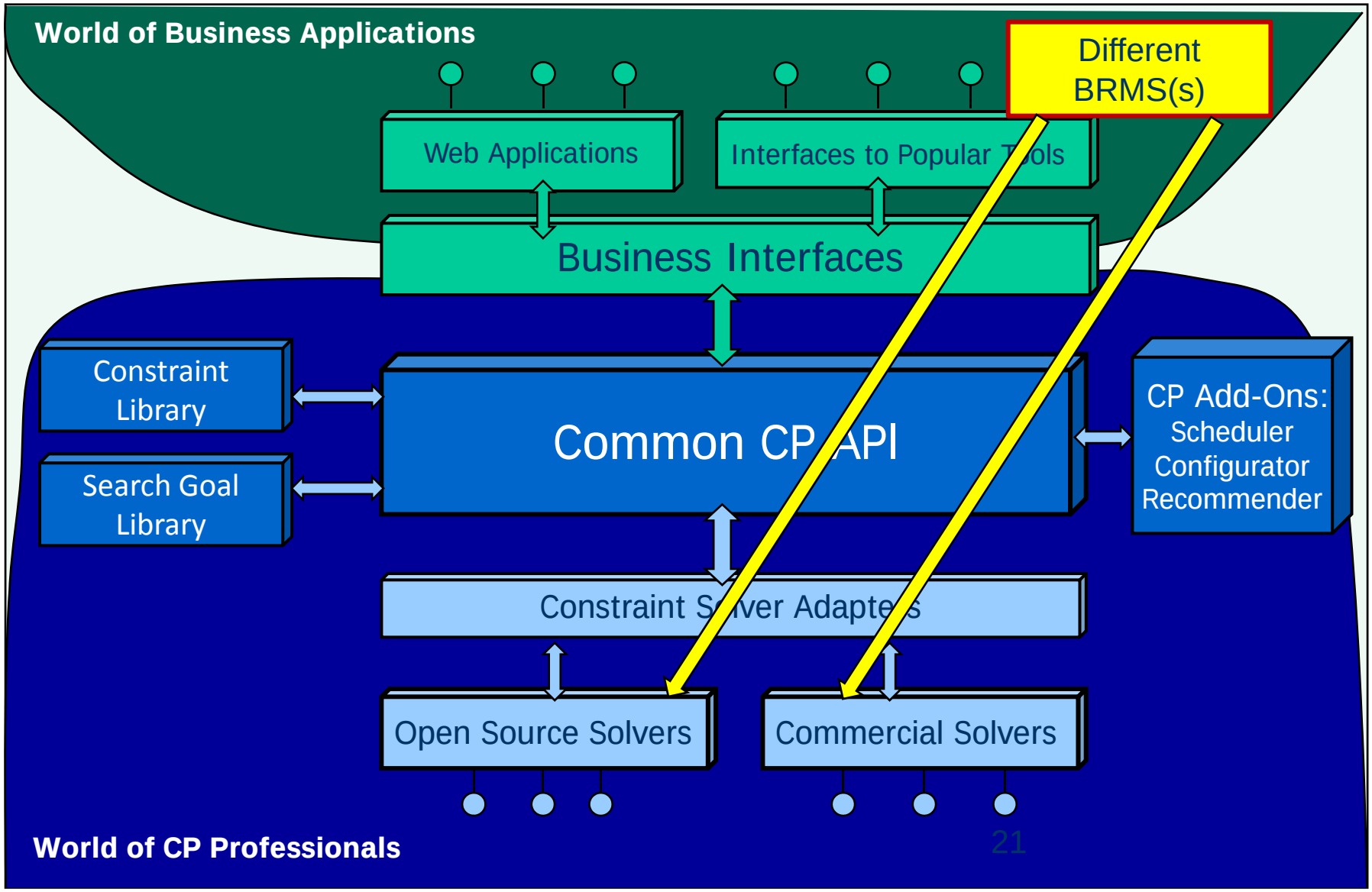
Some Popular CP Tools

- **Java API**
  - **Choco** - Open Source (http://choco.sourceforge.net)
  - **ILOG JSolver** – Commercial (www.ilog.com)
- **C++ API**
  - **ILOG CP** – Commercial (www.ilog.com)
  - **Gecode** – Open Source (www.gecode.org)
- **CP environments with specialized modeling languages**
  - **OPL** from ILOG, France (www.ilog.com)
  - **MiniZinc** from G12 group, Australia (http://www.g12.cs.mu.oz.au)
  - **Comet**, Brown University (www.comet-online.org)
  - **Prolog-based tools** (ECLiPSe, SICStus)
- **20+ other CP Solvers: http://slash.math.unipd.it/cp/**
- **CP Solvers are usually well integrated with other optimization tools (LP, MIP)**

"CP-Inside" Project

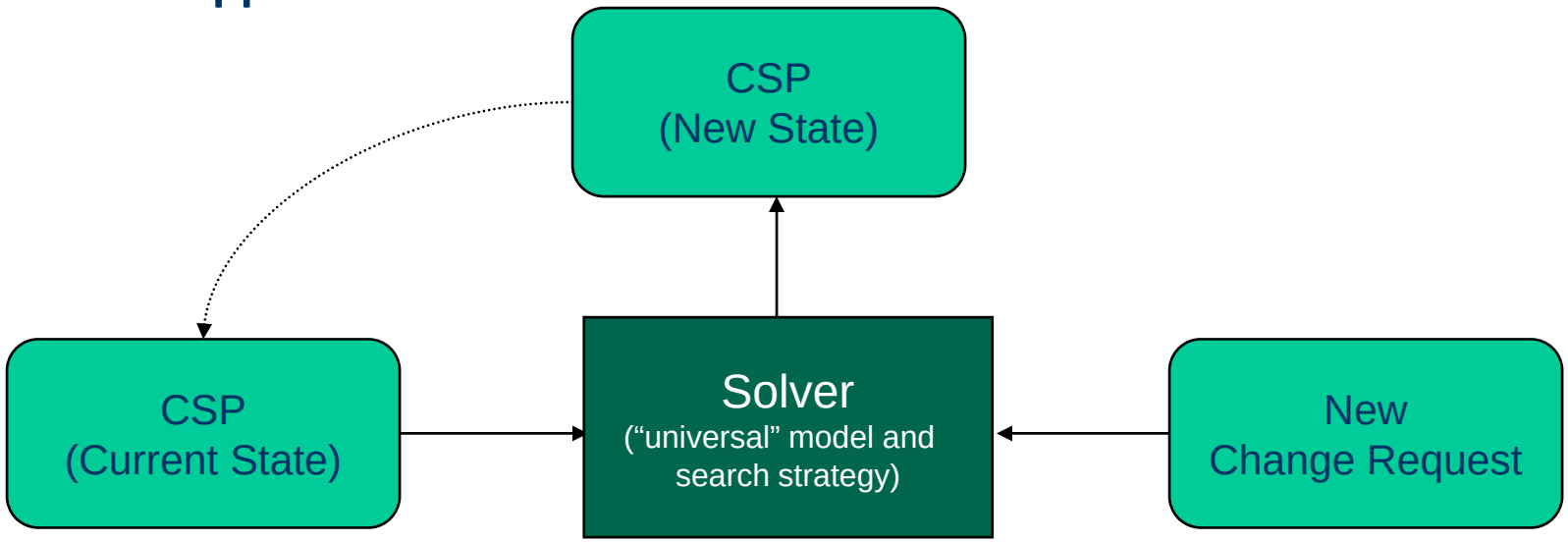
- **Generic interface between different CP Solvers and Business Applications**
  - Created by Cork Constraint Computation Centre (www.4C.ucc.ie) with support from Enterprise Ireland and Science Foundation Ireland
- **Provides a Vendor-Neutral CP API for Java**
  - Adapters to popular open source and commercial CP solvers
  - Common library of constraints and goals
  - Standardization efforts (OMG)
- **Can incorporate CP-based engines in popular software tools:**
  - MS Office (Excel), Rule Engines (OpenRules), Google Calendar and Facebook Events, MatLab, CEP tools, Lotus Notes, and others

CP-INSIDE Architecture (courtesy of www.4c.ucc.ie)



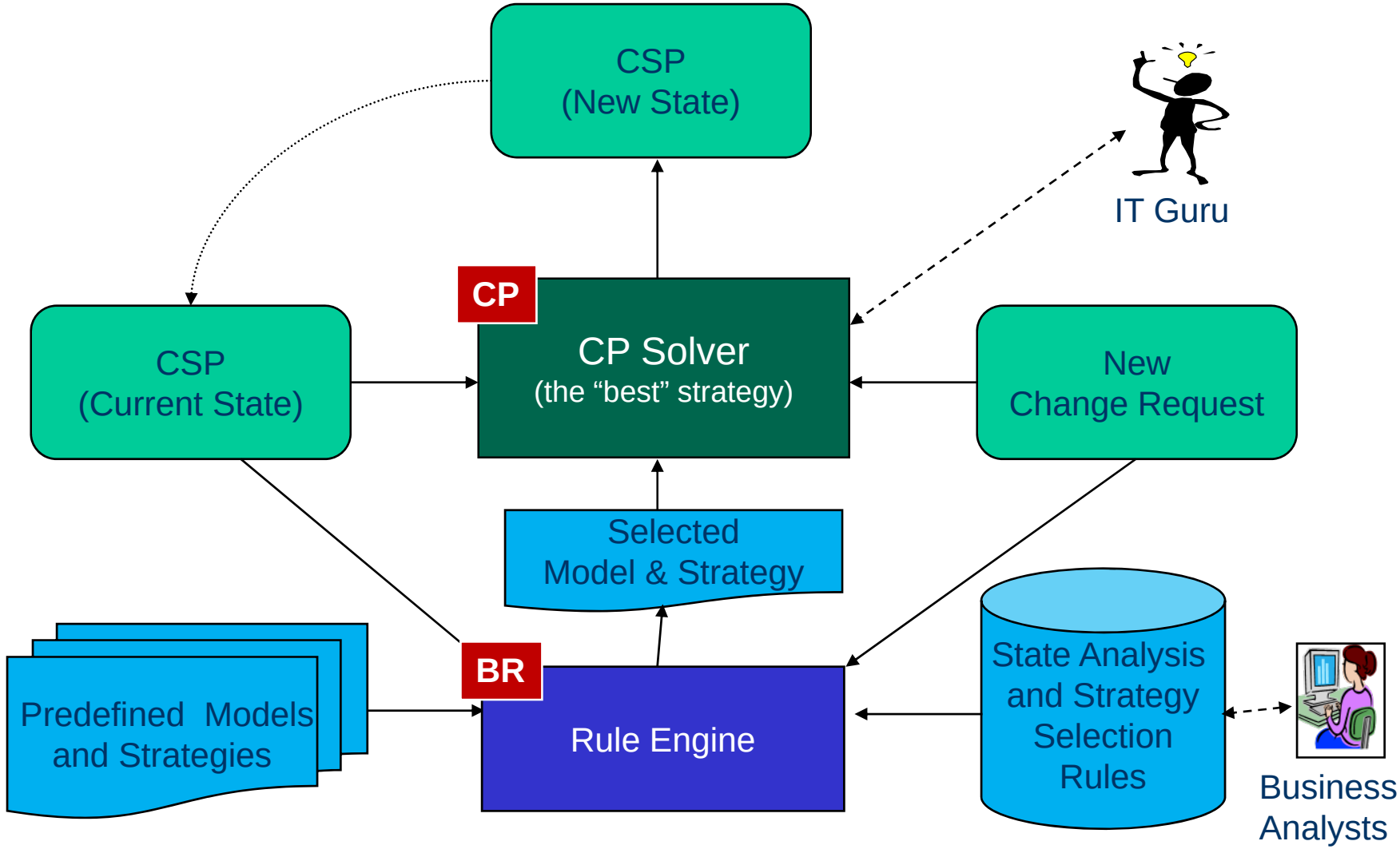
Online Decision Support: modeling and solving constraint satisfaction problems

- **Typical Online Systems with CP-based Solvers:**
  - Online Reservation systems (hotels, tours, vacations, ..)
  - Event Scheduling (both business and personal events in social networks)
  - Field Service Scheduling, and more
- **Traditional Approach:**

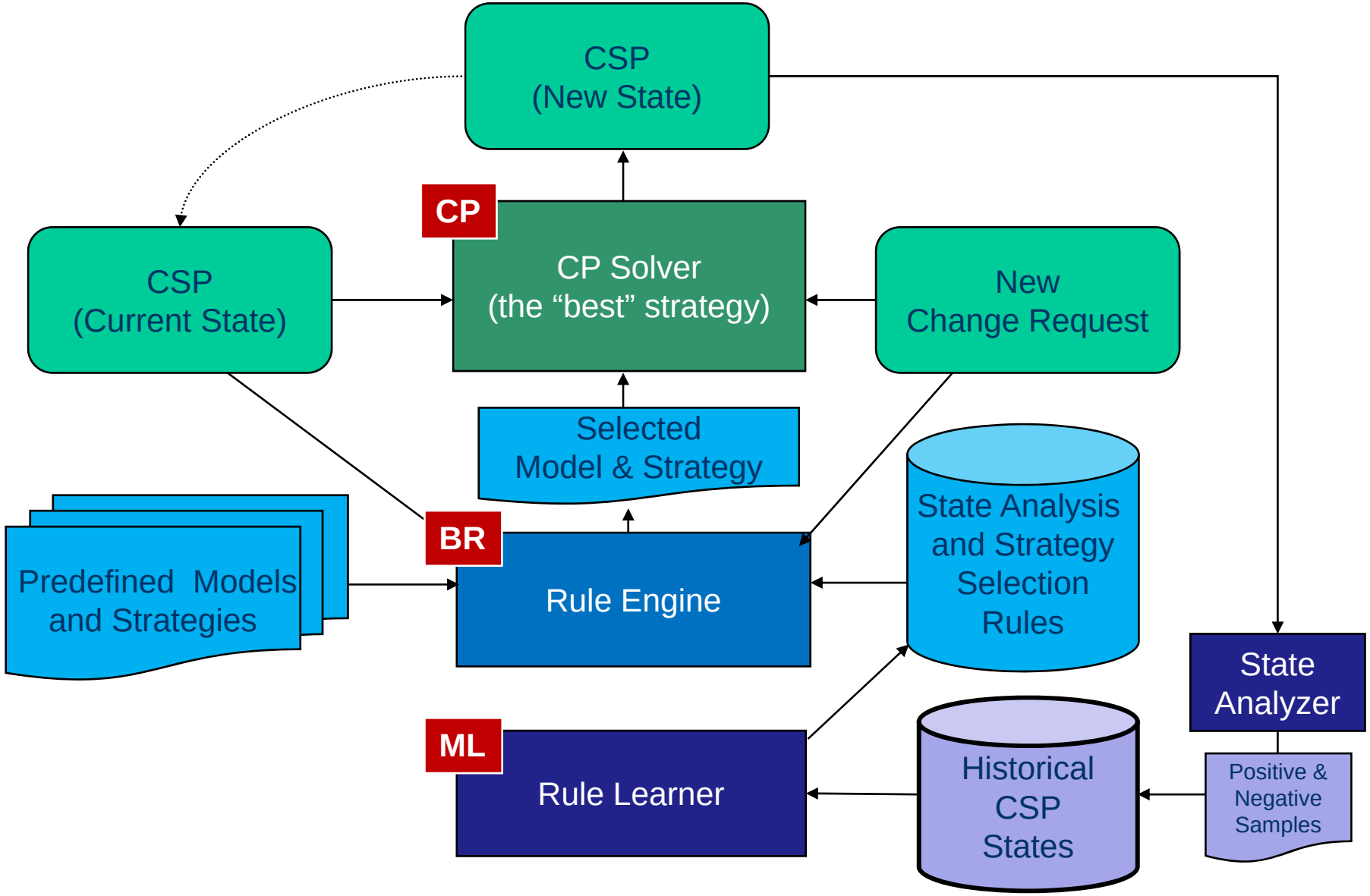


  - "Fat" Problem Solver tuned for all possible problem states
  - Complexity grows over time – hard to create and maintain

Online Decision Support: CP + BR adding Rule Engine to find the "best" strategy



Online Decision Support: adding Rule Learner to find the "best" strategy



Summary

- **Integration of BR and CP empowers a BRMS with much more sophisticated decision-support capabilities**
- **BR+CP methodology and tools are available in a vendor-neutral way**
- **Online decision support may be done with**
  - CP or BR only: Hard to create and maintain "fat" Solver controlled by IT
  - CP + BR: Rule Engine recommends a CSP model and search strategy based on state analysis rules controlled by business analysts
  - CP + BR + ML: Rule Learner discovers model/strategy selection rules based on historical Solver runs – "Ever-learning" decision support