CP-2010

CP Standardization Discussion

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Key Standardization Objectives

- Make CP more accessible for business software developers
- Provide a vendor-neutral standard CP interface(s)
  - Ability to switch between underlying CP solvers without changing application code
- Assist CP vendors in creating practical and efficient standard implementations
- Not to limit innovation

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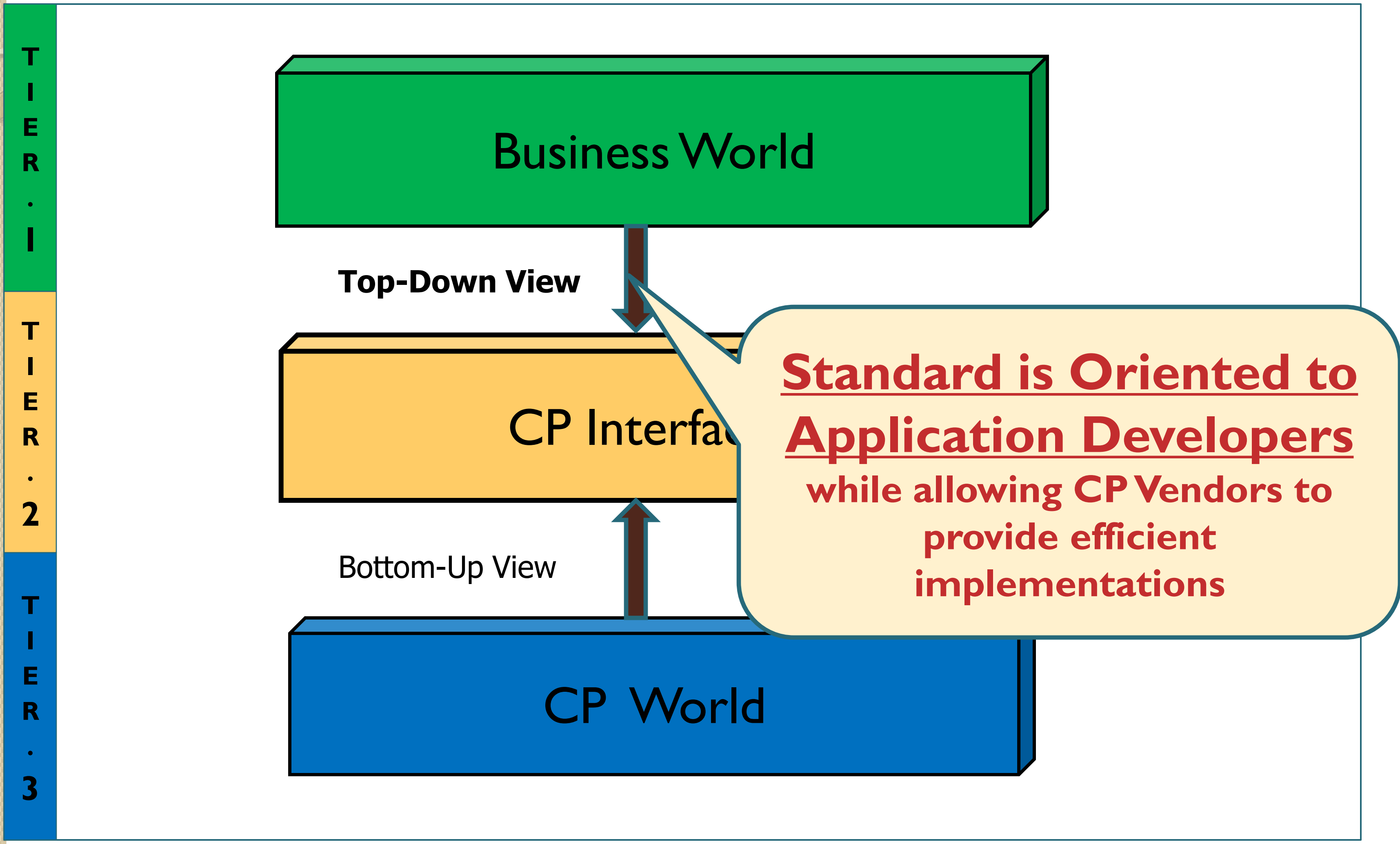
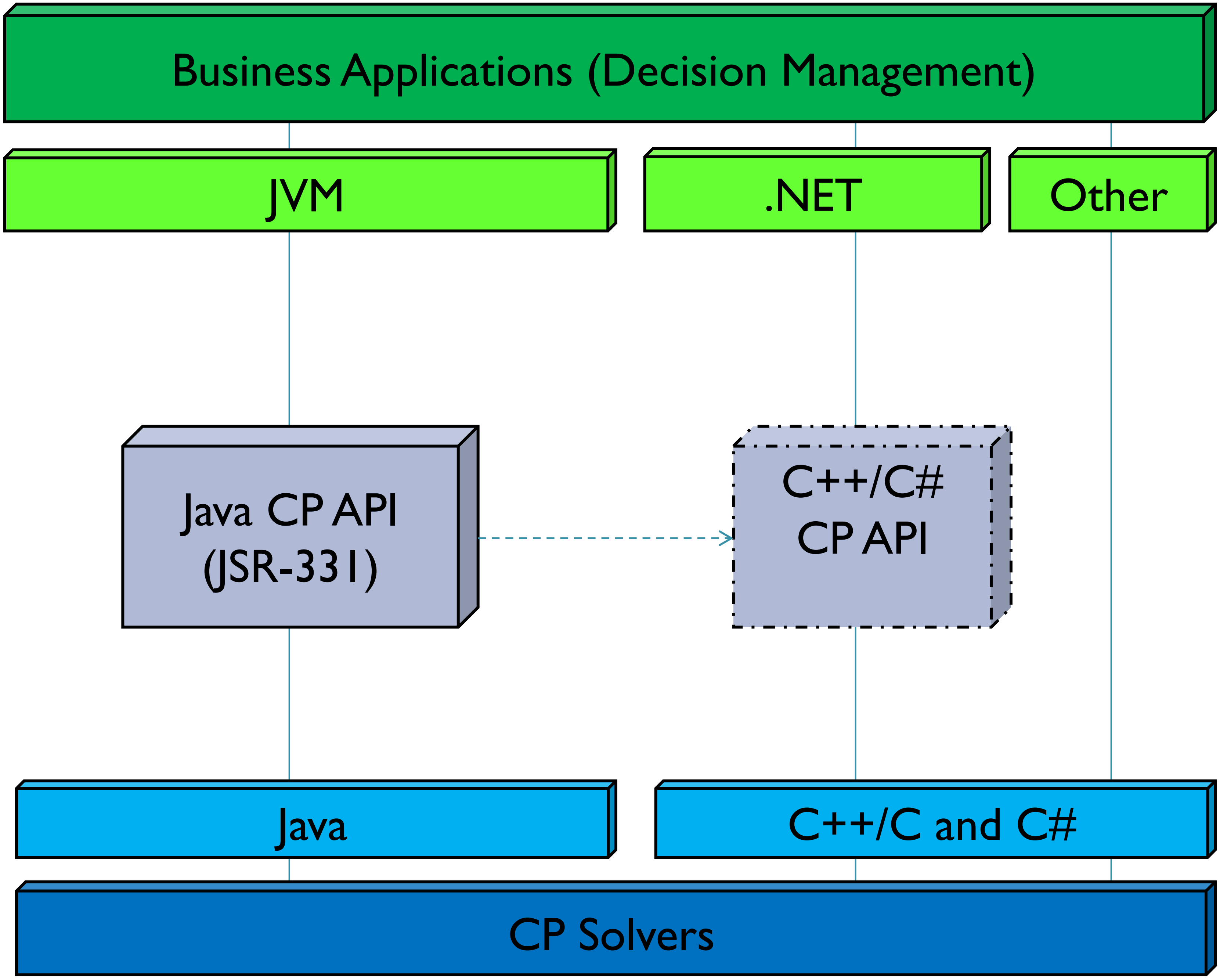
CP Standardization Perspective



Standard is Oriented to Application Developers while allowing CP Vendors to provide efficient implementations


Business Applications (Decision Management)
JVM
.NET
Other
Java CP API (JSR-331)
C++/C# CP API
Java
C++/C and C#
CP Solvers

We started "small"

- Start with only commonly used concepts for CSP Definition and Resolution
- But standard should be extensive enough to solve real-world problems
- Ability to expand later on:
  - Interfaces for Scheduling, Configuration, Routing
  - Interfaces to other solvers (LP, MIP, hybrids, ..)
  - Advanced techniques: explanations, reformulations, visualization, …
- See a roadmap at cpstandard.wordpress,com

JSR-331 – Java Specification Request

- Java Constraint Programming API under the roof of the Java Community Process (JCP) www.jcp.org
- JSR-331 covers key concepts and makes important design decisions related to the Standard Representation and Resolution of constraint satisfaction and optimization problems
- JSR-331Early Draft (a new iteration 0.6.1) is available for public review at www.cpstandards.org

Great Community Input

- Heated Arguments and Constructive Contributions
- Special thanks to:
  - CP vendors:
    - Gecode, Choco, IBM/ILOG, G12, JaCoP, 4C
  - CP experts:
    - Helmut S., Peter S., Nicolas B., and many others
  - Java experts for the JSR-331 Expert Group

Only six major concepts

- Problem
  - ConstrainedVariable
  - Constraint
- Solver
  - SearchStrategy
  - Solution

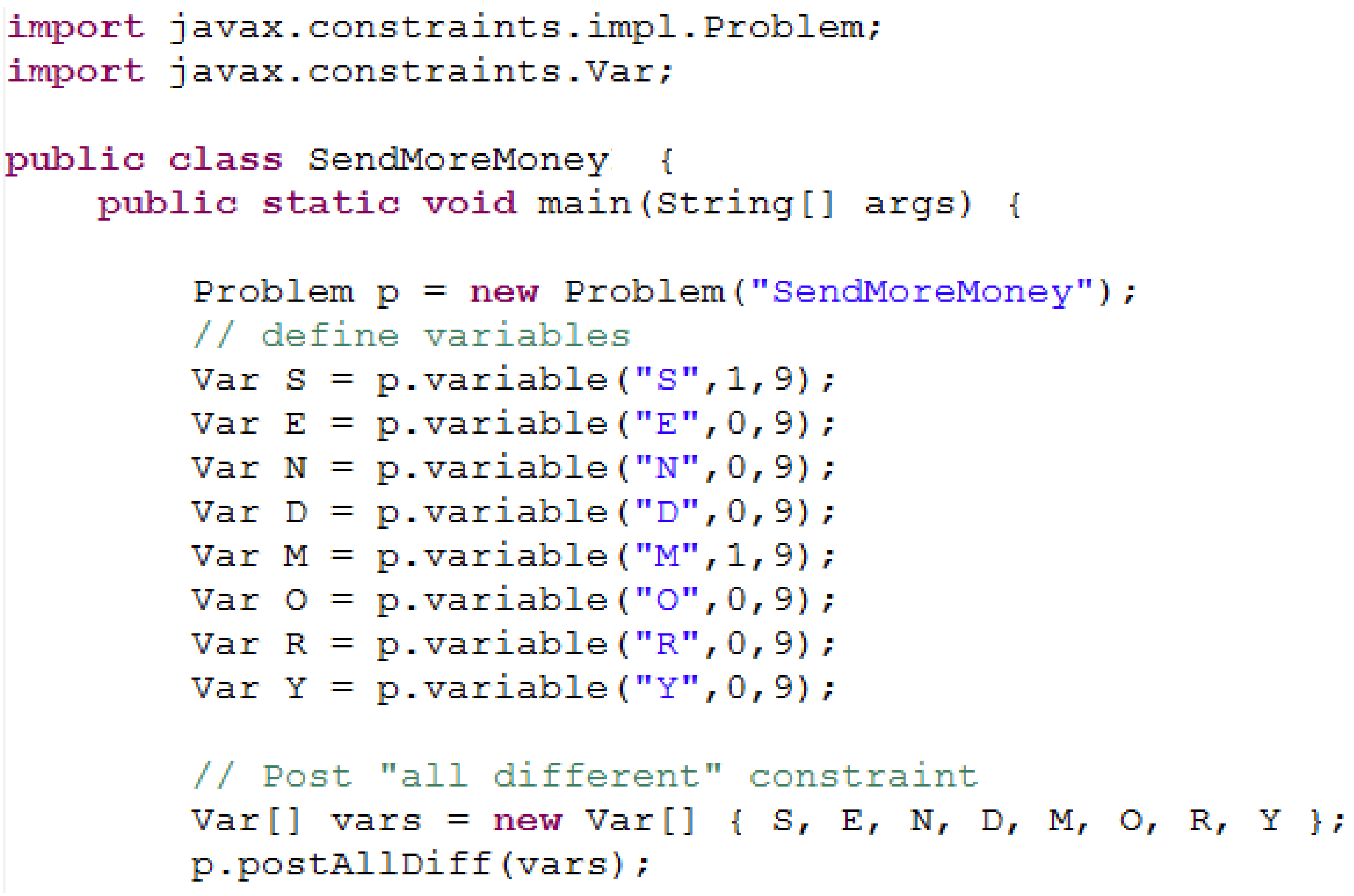
Examples

```
Problem p = new Problem();
Var x = p.variable("X", 0, 10);
Var y = p.variable("Y", 0, 10, DomainType.DOMAIN_SPARSE);
p.post(x,"<",y);
p.post(x.plus(y),"=",z);
p.post(values,vars,"<", 16);
p.postAllDiff(vars);
p.postElement(var, indexVar, ">=", value);
…
Solution solution = p.getSolver().findSolution();
Solution.log();
```

Constraints

- Currently Included:
  - All Basic
  - Linear
  - AllDifferent
  - Element
  - Cardinality
  - GlobalCardinality
- Under Consideration:
  - “regular”,“diffn”, “cumulative”, …

SEND+MORE=MONEY in Java (1)



```
import javax.constraints.impl.Problem;
import javax.constraints.Var;

public class SendMoreMoney  {
    public static void main(String[] args) {

        Problem p = new Problem("SendMoreMoney");
        // define variables
        Var S = p.variable("S",1,9);
        Var E = p.variable("E",0,9);
        Var N = p.variable("N",0,9);
        Var D = p.variable("D",0,9);
        Var M = p.variable("M",1,9);
        Var O = p.variable("O",0,9);
        Var R = p.variable("R",0,9);
        Var Y = p.variable("Y",0,9);

        // Post "all different" constraint
        Var[] vars = new Var[] { S, E, N, D, M, O, R, Y };
        p.postAllDiff(vars);
```

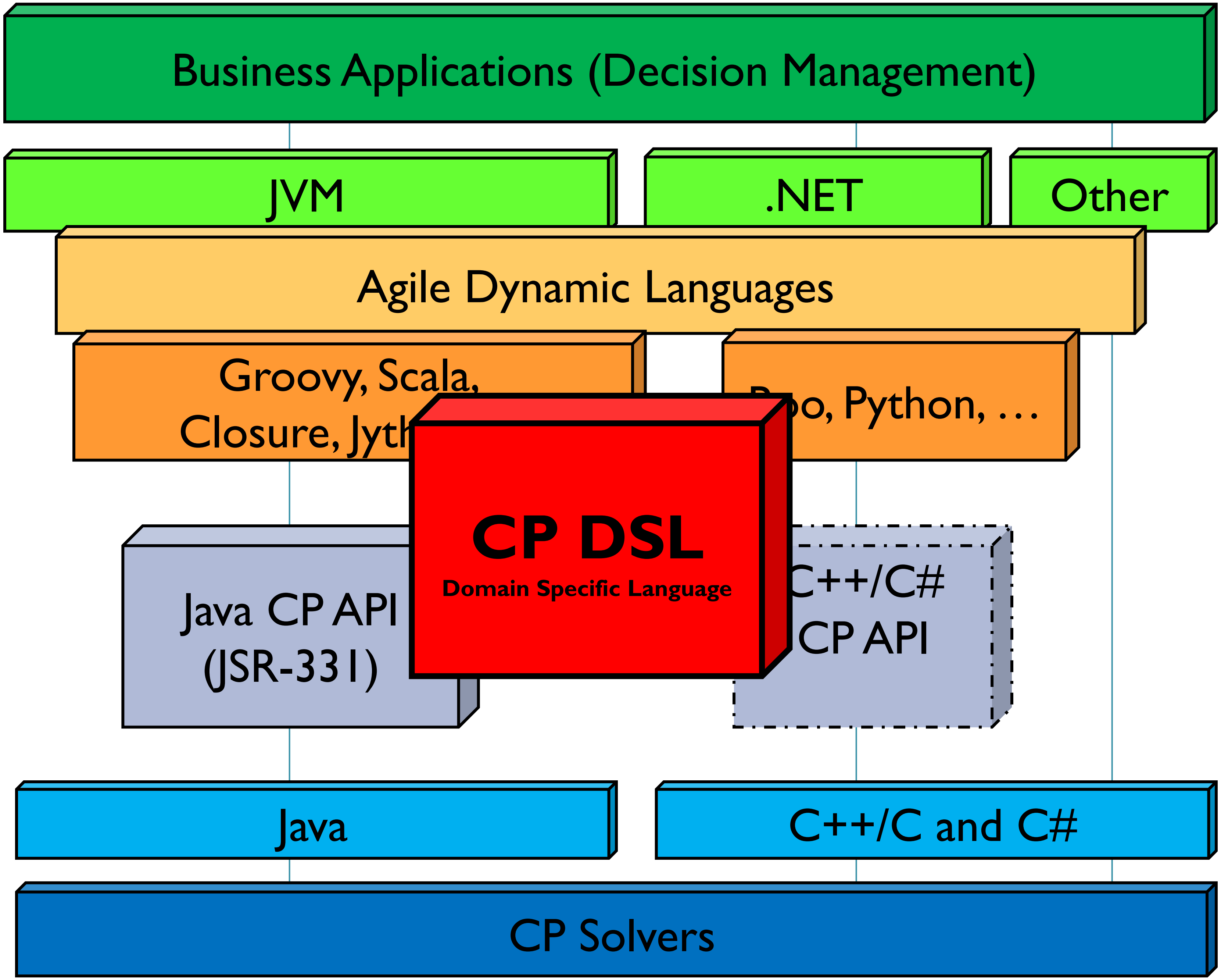
SEND+MORE=MONEY in Java (2)

```
        // Define expression SEND
        int coef1[] = { 1000, 100, 10, 1 };
        Var[] sendVars = { S, E, N, D };
        Var SEND = p.scalProd(coef1, sendVars);
        SEND.setName("SEND");
        // Define expression MORE
        Var[] moreVars = { M, O, R, E };
        Var MORE = p.scalProd(coef1, moreVars);
        MORE.setName("MORE");
        // Define expression MONEY
        Var[] moneyVars = { M, O, N, E, Y };
        int coef2[] = { 10000, 1000, 100, 10, 1 };
        Var MONEY = p.scalProd(coef2, moneyVars);
        MONEY.setName("MONEY");

        // Post constraint SEND + MORE = MONEY
        p.post(SEND.plus(MORE),"=",MONEY);

        // Problem Resolution
        p.getSolver().findSolution();
        p.log("Solution: " + SEND + " + " + MORE + " = " + MONEY);
    }
}
```

Moving From Java To…


Business Applications (Decision Management)
JVM
.NET
Other
Agile Dynamic Languages
Groovy, Scala,
Closure, Jyth
o, Python, …
CP DSL
Domain Specific Language
Java CP API
(JSR-331)
C++/C#
CP API
Java
C++/C and C#
CP Solvers

SEND+MORE=MONEY in Groovy

```
import javax.constraints.groovy.ProblemGroovy;

ProblemGroovy p = new ProblemGroovy("SendMoreMoney");
// define variables
S = p.variable("S",1..9)
E = p.variable("E",[0,1,2,3,4,5,6,7,8,9])
N = p.variable("N",0,9)
D = p.variable("D",0,9)
M = p.variable("M",1,9)
O = p.variable("O",0,9)
R = p.variable("R",0,9)
Y = p.variable("Y",0,9)

p.postAllDifferent([ S, E, N, D, M, O, R, Y ])

// Post constraint SEND + MORE = MONEY
SEND = 1000*S + 100*E + 10*N + D
MORE = 1000*M + 100*O + 10*R + E
MONEY = 10000*M + 1000*O + 100*N + 10*E + Y
p.post(SEND + MORE, "=", MONEY)

// Problem Resolution
p.solver.findSolution()
p.log "Solution: ${SEND} + ${MORE} = ${MONEY}"
```

SEND+MORE=MONEY in CP DSL (?)

```
// define variables
S = variable("S",1..9)
E = variable("E",0..9)
N = variable("N",0,9)
D = variable("D",0,9)
M = variable("M",1,9)
O = variable("O",0,9)
R = variable("R",0,9)
Y = variable("Y",0,9)

postAllDifferent([ S, E, N, D, M, O, R, Y ])

// Post constraint SEND + MORE = MONEY
SEND = 1000*S + 100*E + 10*N + D
MORE = 1000*M + 100*O + 10*R + E
MONEY = 10000*M + 1000*O + 100*N + 10*E + Y
post(SEND + MORE, "=", MONEY)

// Problem Resolution
findSolution()
log "Solution: ${SEND} + ${MORE} = ${MONEY}"
```

JSR-331 – Java Specification Request

- JSR-331Early Draft will be finalized soon
- Provide comments at www.cpstandards.org and contribute to creation of the Technology Compatibility Kit (TCK)
- There are 3 working JSR-331 implementations: more are welcome. Send download requests to j.feldman@4c.ucc.ie
- Finally, JSR-331 has been nominated by JCP to the most innovative JSR of 2010. It is an honor, but:
  - It tells more about unfamiliarity of Java world with CP
  - It will contribute to CP recognition among Java developers

Discussion Panel

- Peter Stucky (G12)
- Laurent Michel (Comet)
- Chris Jefferson (Minion)
- Nicolas Beldiceanu (Choco)
- Radek Szymanek (JaCoP)
- Helmut Simonis

Discussion Topics

- CP API for main-stream languages
- JSR-331
- CP DSL
- CP XML
- Standard Test Problems
- Integration with MIP/LP
- Integration with Rule Engines, Office,…
- Vertical Add-Ons
- Others

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