Code Generation in the World of Business Rules

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Background

- Definitions of business rules range from:
  - "A nice way to write reasonable analysis documents"

to

  - "The system itself"

- Implementation rules => Developer's world
- Analysis rules => System Architect's world

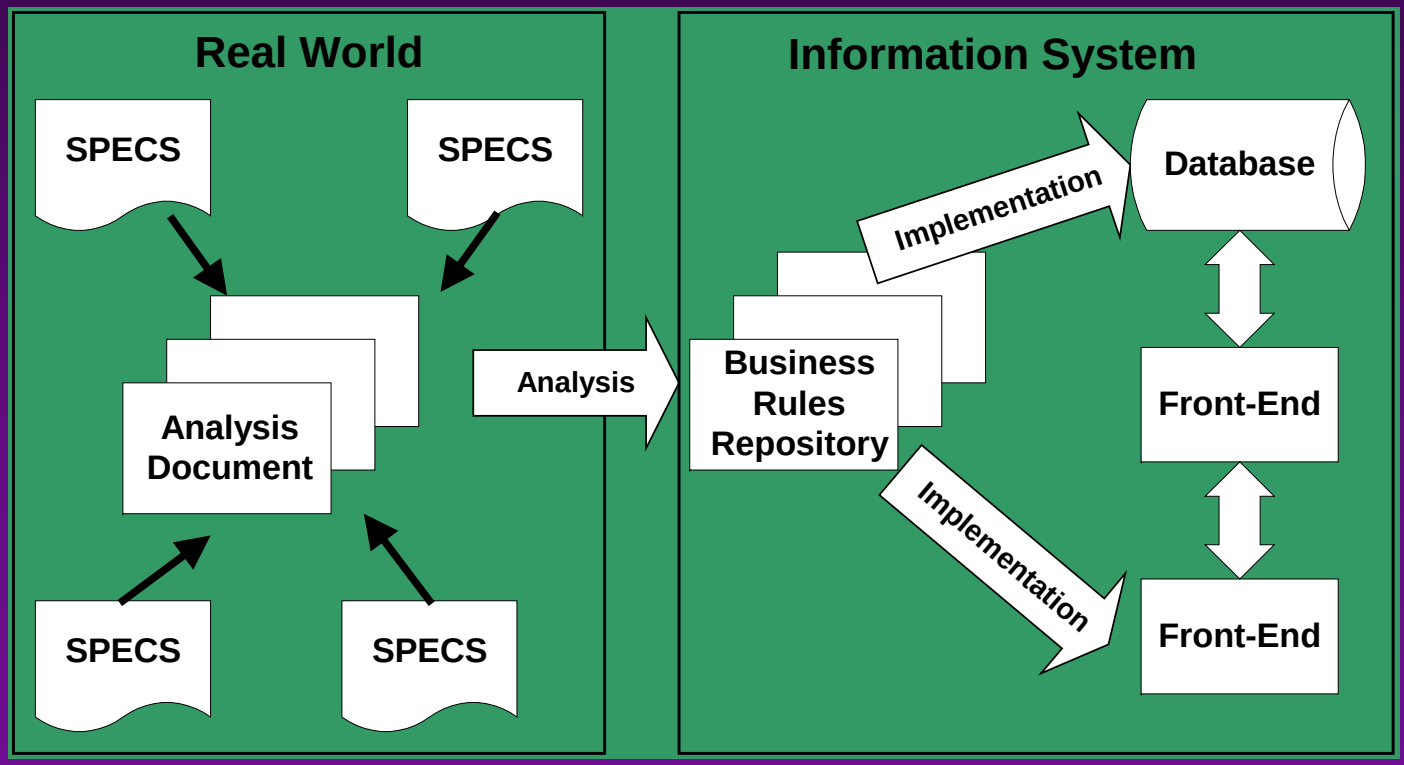
Part 1:
Rule-Based Systems -
Repository Access Approaches

Business Rule-Based Systems

- Flexible enough => to allow for future modifications which may not be foreseen at the time of development
- Scalable enough => to handle significant data growth over time
- Generic enough => to survive a significant platform/front-end change (Java, JSP, JSF, XMLDB....etc.).
- Fast enough => to produce specified level of performance, given limited resources

Business Rules Repository: Real world and IT

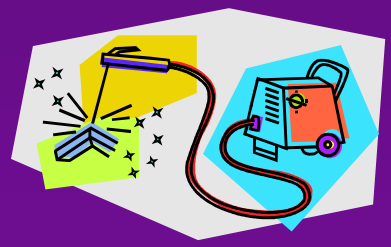
- Developers use SQL and analysts use English.
- Business rules have to be centrally stored in the database to communicate.



Business Rules Repository: Access Approaches

Since the repository is inside of the database:

- Workflow can be dynamically controlled.
  - **Interpreters** => run-time access to business rules
- Workflow could be represented as database objects.
  - **Generators** => run-time access to generated objects

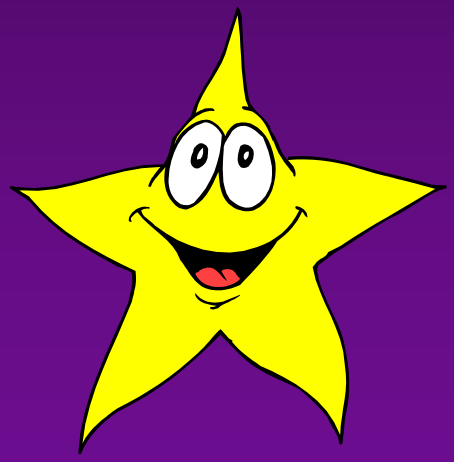


Interpreted access example

- Business rule: “The start date of an employee’s timesheet should not be later than its end date.”
- Implementation:
  - Detect validation point.
  - Find appropriate rule in the repository.
  - Translate rule from business terms to database terms.
  - Validate original object using interpreted rule.
  - Interpret the result.
  - Flag main routine regarding the success or failure of the rule and execute appropriate actions.

Pros and Cons of Interpreters

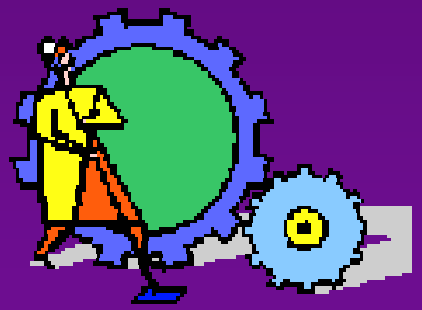
- Pro:
  - Changes to business rules and changes to their interpretation have an immediate impact on the system.



- Con:
  - Major performance drawback because the database must perform many operations just to compare two dates.

Generator example

- Business rule: “The start date of an employee’s timesheet should not be later than its end date”.
- Implementation:
  - The validation firing point should be the state change of the timesheet from NotSubmitted to Submitted.
  - In the database, that rule could be implemented on the BEFORE UPDATE trigger
  - If a rule fails, an exception must be raised



Example Code

```
CREATE OR REPLACE TRIGGER timesheet_bu
 BEFORE UPDATE ON timesheet
REFERENCING NEW AS NEW OLD AS OLD
Begin
  if updating('state_cd')
  then
    if :new.state_cd='Submitted' then
      if :new.start_dt>=:new.end_dt then
        raise_application_error(-20999,
           'Rule 10 violated: start date
                 cannot be later than end date');
      end if;
    end if;
  end if;
end;
```

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Pros and Cons of Code Generation

- Pros:
  - Performance benefits

- Cons:
  - Any modification to the business rule now will require regeneration of the objects that reference it.
  - Significant problems in a production system because of Oracle feature of invalidating all objects referencing recompiled ones.

Common feature of both approaches

- Both approaches have one major concept in common:

The implementation of the business rules is independent of their specification.

- Business rule: “Start date of the employee’s timesheet should not be later than its end date”
  - No mention of tables, columns, queries etc.
  - System architect’s problem to determine the appropriate implementation mechanism.

Implementation differences

- Interpreted approach
  - Translate the rules into database terms and the results from the database terms by generating SQL, XML, conversion maps etc.
- Compiled approach
  - Generate database or other objects using PL/SQL, Java, XML, JSPs, etc. in order to implement the business rules.

Role of generators in rule-based system

- Generators can be tuned or changed without touching the business rules.
- Expected performance could be achieved without a major re-architecting of the system.
- If new requirements can be stored in the repository, the generators can be updated to support them.
  - Other parts of the system will not be affected by the changes.
- Generation algorithms can be changed depending upon the available data volume, system configuration, etc.
- Generators can be substituted or extended to work with other languages and platforms without altering the business rules.

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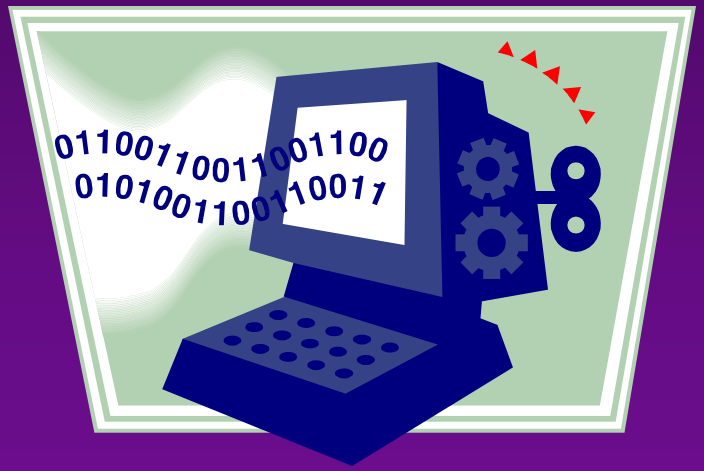
Important!

No business rules-based system can be implemented without some type of code generator.



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Part 2: Interpreters

Interpreters

- In the world of business rules:
  - "Interpreted" ~ queries are built on the fly via generic routines.

```
Begin
   Execute immediate "select … from … " into
     …;
End;
```

  - Generic routines cover all possible tasks as broad as possible.
  - Repository is accessed each time we need to build executable code.

Interpreters: 1. Declarative generators

- Many attempts to create a pseudo-language to allow definition of rule written in English to be easily translated into a set of database commands and conditions.
- Most attempts did not perform as promised.
- Few IT environments need to support thousands of declarative rules:
  - (Ex. “If gender is male and age is above 45, then recommend yearly heart checkup”).
  - Even in very large systems, there may only be a few hundred of them spread around the large data or process model.

State Transition Engine Example

- Transition with the rule on it.
  - If it succeeds, the object will be moved to the state "Recommend heart checkup."
- From the repository point of view, the rule should look like:

```
RuleId: 11
BelongsTo: Transition 10
RuleText: gender is male and age is above 45
```

Solution

- Add one extra column for each implementation environment (SQL, Java etc).
- Column is populated after the first cycle of analysis by the software developer based on the text of the rule:

```
ExecutableRule:
emp.gender='Male' AND emp.age>=45
```

Generic validation routine

- Pass *table* (where the object is stored), *primary key*, and *column* to store the primary key into the function => allow the system to uniquely identify the desired *object*.
- Pass *transition* to be able to select the applicable *rules* and their translation to PL/SQL.
- Use Dynamic SQL => check *rules* against identified *object*.

Generic validation routine

```
function f_validate (pin_pk_id number,  pin_pk_column_cd varchar2,
                     pin_class_cd varchar2, pin_trans_id number)
return boolean is
    cursor c1 is
    select ExecRuleTx from ste_rule where trans_id = pin_trans_id;
    ...
begin
    open c1;
    loop
        fetch c1 into v_rule_tx;
        exit when c1%notfound or v_hasfailedrule_b=true;
        execute immediate 'select count(*) from '||pin_class_cd||
                          ' where '||pin_pk_column_cd||'='||pin_pk_id||
                          ' and ('|| v_rule_tx ||')' into v_out_nr;
        if v_out_nr=0 then
          v_hasfailedrule_b:=true;
        end if;
    end loop;
    close c1;
    return v_hasfailedrule_b;
end;
```

Interpreters: 2. Event-Condition-Action Generators

- A set of UI elements:
  - button1 (named “Set Default End Date”),
  - textField1 (contains start date),
  - textField2 (contains end date)
- Elements may have events
  - button1 is associated with the event “Press.”
- Events may have conditions:
  - “End date is null.”
- If the condition is satisfied, the event has a set of actions:
  - Set end date equal to start date + one month both on the screen and in the database.
  - Disable the end date field.

Algorithm

- Notify the database about the event.
- Generate a list of appropriate actions
- Check all corresponding rules for each action.
- Retrieve the list of actions that correspond to the event
- Interpret list of actions at the client side into tool-specific command

Example

```
function f_checkRule (pin_astion_id number) is
    cursor c1 is
    select r.condition_tx, r.executable_rule_tx, r.Class_CD
    from ar$rule r
    where action_id = pin_action_id;
    ...
begin
    open c1;
    loop
        fetch c1 into v_rec;
        exit when c1%notfound or v_hasfailedrule_b=true;
         execute immediate
     'select count(*) from '||c.Class_CD||
     ' where '||pin_pk_column_cd||'='||pin_source_object_id||
     ' and ('|| v_rec.executable_rule_tx ||')' into v_out_nr;
           if v_out_nr=0 then
              v_hasfailedrule_b:=true;
           end if;
    end loop;
    close c1;
    return v_hasfailedrule_b;
end;
```

Interpreters: 3. Communication Interface Generators

- Requirements:
  - Front-end environment working against XML-based forms.
  - Set of APIs only worked with specially formatted XML documents.
- Problems:
  - Can't expect changes in the API
    - Need to create two-way parser
  - Documents are specially formatted
    - Not possible to use internal XML parsers from the database.

Solution: Database to XML

- Map existing data into the appropriate XML tags. (discussed later)
- Generate an XML-document procedurally as a regular text document from the maps.
- Store the original CLOB in the table.
- Query CLOB from the client side.
- Convert the text into an XML-document.
- Apply the required APIs.

Solution: XML to Database

- Compare the modified XML-document with the master copy.
- Store the differences as CLOBs in the table.
- Map XML tags to real columns.
- Update identified columns with new values.

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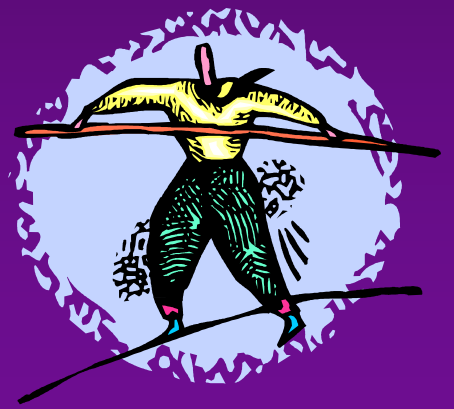
Challenges

- Manual creation of XML
  - Some characters are special for XML (“>”,”<”,”&”,” %”)
  - Others could be special in the database (single quotes, characters from different languages).
- A converter of strings into the XML-compatible format may be useful.



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Part 3: Compilers

Compilers

- In the world of business rules:
  - "Compiled" ~ some physical objects (tables, procedures, files etc.) will be created.

```
Begin
   Execute immediate "create or replace package …";
End;
```

  - Objects fully (or as much as possible) represent the set of business rules
  - Executable code will need to access the repository fewer times.

Compilers: 1. Data Models

- Data models represent structural business rules.
- Dynamic SQL => all database objects (tables, views, constraints, triggers) could be generated from the repository
- More than one way to implement the same rule:
  "field <gender>can only have values male/female" :
  - FK from the EMP table to the reference table.
  - Check constraint on EMP
  - Before-Update trigger
- Possibility to rename/alter items in real time => implement business rule changes on the fly.

Main task:
Create Original Code

- Purpose:
  - Test versions
  - Quick prototypes

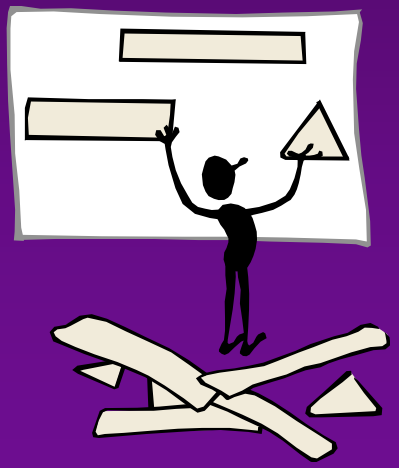
- Advantage
  - Using the generator means that you always know what is going on in the database.
- Challenge
  - Limited notation of ERD => problem of implementing UML in relational database

Example

- Maintaining historical records on a class.
  - Add two new columns to the table:
    start_dt and end_dt
  - Add three new columns to the view:
    start_dt, end_dt and active_yn
  - If end_dt is populated => object is inactivated.
  - If end_dt is set to Null => object is reactivated.
  - Add Before-(Insert, Update, Delete) to the view to prevent any activity on the object if it is inactivated except for update of end_dt

Main task: Maintain changes

- Purpose:
  - Implementation of changes to the rules repository
- Challenge
  - Need to maintain a strict one-to-one relationship between the definition of a business rule and its implementation.



Example

- Modify name of the class

```
procedure setTableName(in_class_id number,
                       in_oldclasscode_tx varchar2,
                       in_newclasscode_tx varchar2) is
  v_ddl_tx varchar2(2000);
begin
  v_ddl_tx:='rename '||in_oldclasscode_tx||
                ' to '||in_newclasscode_tx;
  execute immediate v_ddl_tx;

  v_ddl_tx:='alter table '||in_oldclasscode_tx||
  ' rename column '||in_oldclasscode_tx||||'_OID ||
              ' to '|| in_newclasscode_tx||'_OID';
  execute immediate v_ddl_tx;
end;
```

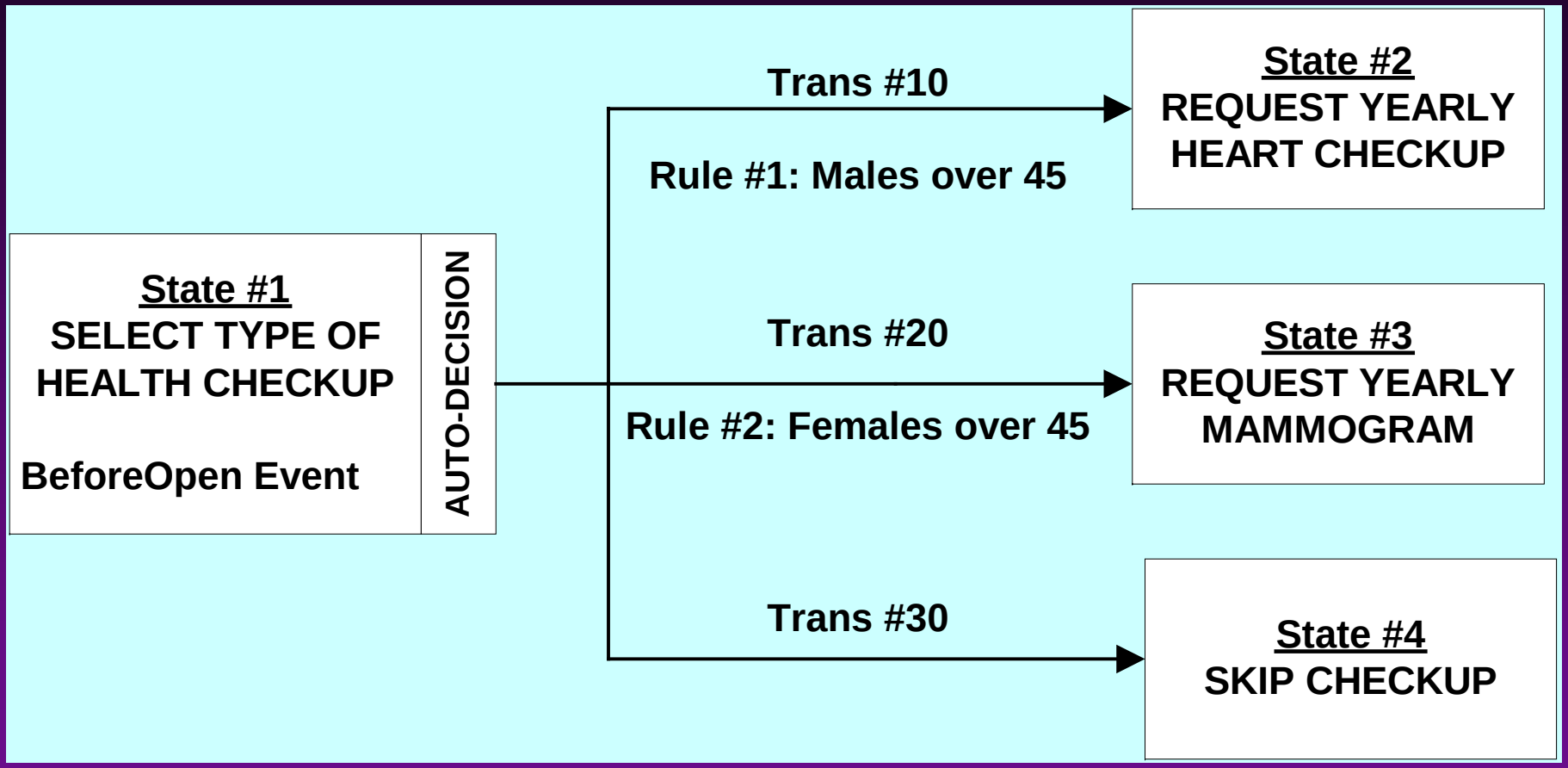
Compilers: 2. Process models

- A workflow can (and sometimes should) be represented as generated code.
- Major drawback of implementing advanced process flows is the large number of repository requests.
- If all communications between different states of the flows could be generated, not much else is required.

Dulcian STE notation

- Extension of UML activity diagram:
  - Classes can have workflows consisting of states.
  - States can have events.
  - States are connected by transitions.
  - Transitions are initiated by special kinds of events.
  - Transitions can have rules. If a rule fails, then navigation via the transition is impossible.
  - Events can have rules. If a rule fails, then the event is aborted.
  - Events and transitions can have corresponding tasks.

Sample state with transitions



Example

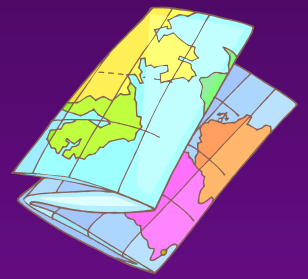
```
procedure p_auto_1(SelfOID in Number) is
Begin
  /*BeforeOpen*/
  emp.setHealthValidationDt(sysdate);
  /*:HealthValidatoinDt:=sysdate*/

  if (emp.getAge(selfOID)>=45 and emp.getGender(selfOID)='Male')
   then
  /*(:Age >= 45 and :Gender='Male')*/
    ste$pkg.setState(SelfOID,2,10); --object,state,transation
  elsif (emp.getAge(selfOID)>=45 and
   emp.getGender(selfOID)='Female') then
  /*(:Age >= 45 and :Gender='Female')*/
    ste$pkg.setState(SelfOID,3,20); -- object,state,transation
  elsif 1=1 then
  /*No Rule*/
    ste$pkg.setState(SelfOID,4,30);
end if;
End;
```

Advantages of extended UML notation

- Higher level of abstraction in the definition of a state (about 1 high-level state for every 60 in a regular flowchart)
- Smaller number of logical structures involved (IF..THEN, LOOP, etc.) => simplify the code
- Predefined and limited number of events => precisely identify the elements to be generated
- Any event (with rules and tasks) can be represented as a set of commands in any procedural language.
- Any transition (with rules and tasks) can be represented as a set of commands inside of the initiating event.

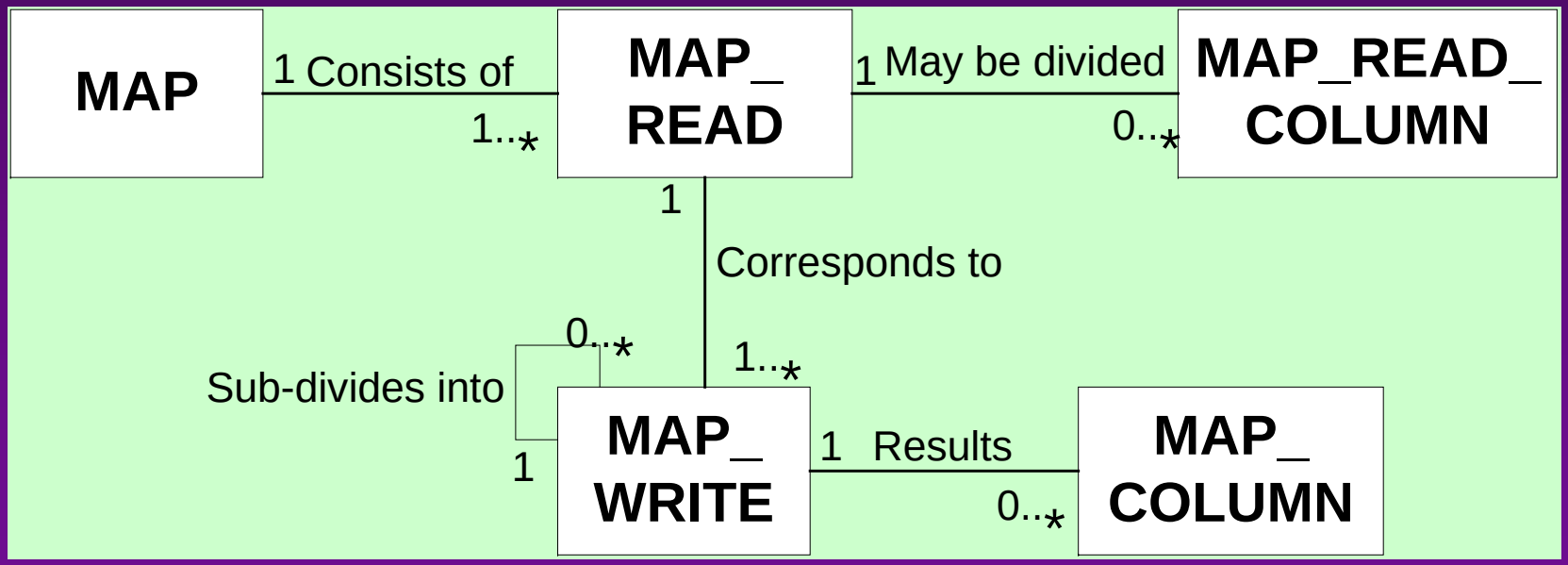
Compilers: 3. Data mappings

- Problem working with XML-based forms:
  - Architecturally, forms were exact copies of the paper forms
  - Data model was significantly different from what was shown on the screen.
- Challenge:
  - Map stored data into XML tags.
  - Mandatory to decrease workload on the client machines.



Solution

- Full two-way conversion of stored data into the precise data representation required for the client code.
- Special mapping repository was created to carry out the conversion.



Solution (continued)

- Originally DB→XML and XML→DB maps were used.
- Later this architecture was extended to support DB←→DB maps => extremely powerful migration utility
  - Generic definition of the source and target => migration maps between completely different data models of any level of complexity.

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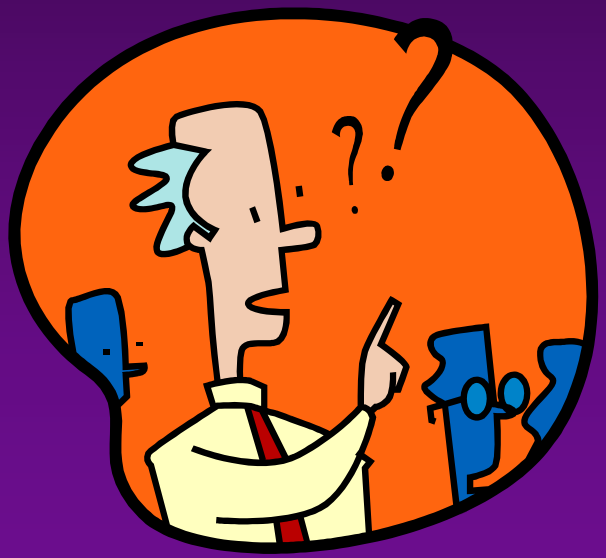
Conclusions

So what?



Advantages of using generators

- Build systems "better":
  - Improve flexibility, performance, maintainability, scalability etc
- Build systems "faster":
  - 90% of the code is generated => less time to create, less time to implement the change
- Build systems "cheaper":
  - Shorter development cycle.
  - One top-level developer is still cheaper than 10 low-level
  - Less chance for human mistakes, miscommunication etc.

Guidelines for using code generators

- Keep them in mind from the very beginning of the project.
  - Flexible data sources => generate queries
  - Logical processing => generate workflows
  - Process a lot of data => generate batch workflows
  - Future extensions of the system => generate data model
  - Data transformations => generate maps
  - Communication with other language systems => create converters.

Dulcian's BRIM® Environment

- Full business rules-based development environment
- For Demo
  - Write "BRIM" on business card
- Includes:
  - Working Use Case system
  - "Application" and "Validation Rules" Engines

Contact Information

- Michael Rosenblum mrosenblum@dulcian.com
- Code examples from these slides are available in the accompanying paper on the Dulcian website

  www.dulcian.com
- See Conference Papers and Presentations/Presentations by Conference/ODTUG 2005