POO

Sabloane de proiectare creationale

Cuprins

- sabloane de proiectare (software design patterns)
- sabloane creationale
  - Singleton
  - Builder
  - Object Factory

Sabloane de proiectare (Design Patterns)

- intai aplicate in proiectare urbanistica:

  C. Alexander. A Pattern Language. 1977

- definitia originala a lui Alexander: *"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice"*

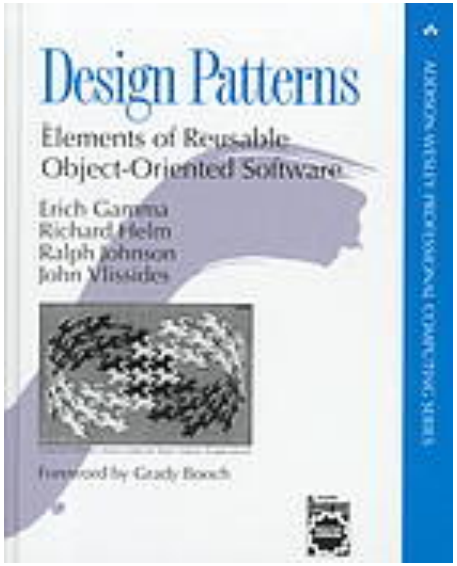
- prima contributie in software: 1987, Kent Beck (creatorul lui Extreme Programming) & Ward Cunningham (a scris primul wicki)

Aplicarea sabloanelor in POO

- contributia majora: Design Patterns:

  Gamma et al. Elements of Reusable Object-Oriented Software was published, 1994

  - cunoscuta ca **GoF** (Gang of Four)
  - pot fi aplicate la nivel de clasa sau obiect



- GoF include 23 de sabloane

Formatul (template) complet al unui sablon

- nume si clasificare
- intentie
- cunoscut de asemenea ca
- motivatie
- aplicabilitate
- structura
- participanti
- colaborari
- consecinte
- implementare
- cod
- utilizari cunoscute
- sabloane cu care are legatura

Clasificarea sabloanelor GoF

- creationale
  - utilizate pentru crearea obiectelor
- structurale
  - utilizate pentru a defini structura (compunerea) claselor sau obiectelor
- comportamentale
  - descrie modul in care clasele si obiectele interactioneaza si isi distribuie responsabilitatile

POO

Singleton

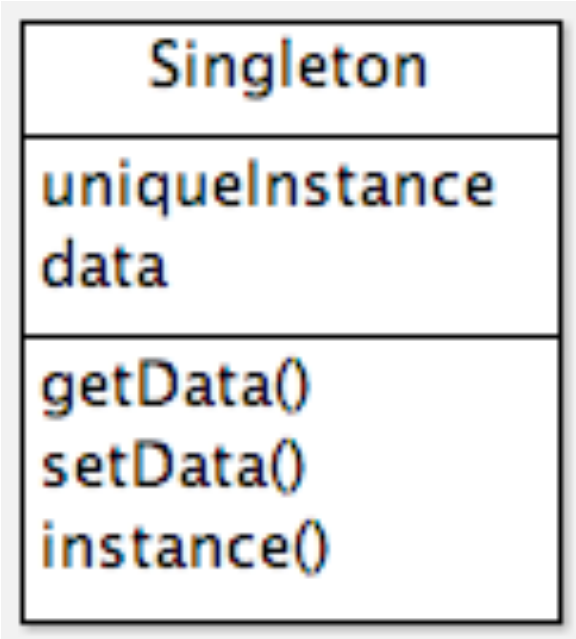
(prezentare bazata pe GoF)

Clase cu o singura instanta (Singleton)

- Intentia
  - proiectarea unei clase cu un singur obiect (o singura instanta)
- Motivatie
  - intr-un sistem de operare:
    - exista un sistem de fisiere
    - exista un singur manager de ferestre
  - intr-un sit web: exista un singur manager de pagini web
- Aplicabilitate
  - cand trebuie sa existe exact o instanta
  - clientii clasei trebuie sa aiba acces la instanta din orice punct bine definit

Clase cu o singura instanta (Singleton)

- structura



- participant: Singleton
- colaborari: clientii clasei

Clase cu o singura instanta (Singleton)

- Consecinte
  - acces controlat la instanta unica
  - reducerea spatiului de nume (eliminarea variab. globale)
  - permite rafinarea operatiilor si reprezentarii
  - permite un numar fix de instante
    - Doubleton
    - Tripleton
    - ...
  - mai flexibila decat operatiile la nivel de clasa (statice)
- Implementare

cum?

Clase cu o singura instanta

```
template <typename Data>
class Singleton {
public:
  static Singleton<Data>& instance() {
    return uniqueInstance;
  }
  Data getData() { return data; }
  void setData(Data x) { data = x; }
protected:
  Data data; // campurile care descriu starea instantei
  Singleton() { }
  void operator=(Singleton&);
  Singleton(const Singleton&);
private:
  static Singleton<Data> uniqueInstance;
};
```

manerul cu care se are acces la instanta

metode care opereaza peste instanta unica

constructor

operator atribuire

constructor de copiere

instanta unica

Clase cu o singura instanta

```
template <typename Data>
Singleton<Data> Singleton<Data>::uniqueInstance;

int main() {
  Singleton<int> &s1 = Singleton<int>::instance();
  cout << s1.getData() << endl; // 0
  Singleton<int> &s2 = Singleton<int>::instance();
  s2.setData(9);
  cout << s1.getData() << endl;  // 9
  Singleton<int> &s3 = s2;
  cout << s3.getData() << endl;  // 9
}
```

initializare

refera aceeasi instanta
(pe cea unica)

Clase cu o singura instanta

- daca se comenteaza constructorul de copiere, atunci se poate executa urmatorul cod:

```
Singleton<int> s4 = s2;
s4.setData(23);
cout << s4.getData() << endl; // 23
cout << s2.getData() << endl; // 29
```

- operatorul de atribuire se declara privat doar pentru a evita operatii fara sens ca:

```
s4 = s2;
```

- in lipsa accesului la constructori, operatorul de atribuire nu poate fi utilizat pentru doua instante diferite

Demo

C++ 2011

- interzicerea utilizarii unor functii/metode se poate face printr-o declaratie **delete**
- din manual (8.4.3):

"1 A function definition of the form:

attrib-specifier-seqopt decl-specifier-seqopt declarator = **`delete`** ;

is called a **deleted definition**. A function with a deleted definition is also called a deleted function.

2 A program that refers to a deleted function implicitly or explicitly, other than to declare it, is ill-formed.

[Note: This includes calling the function implicitly or explicitly and forming a pointer or pointer-to-member to the function. It applies even for references in expressions that are not potentially-evaluated. If a function is overloaded, it is referenced only if the function is selected by overload resolution. — end note]"

C++ 2011

- inhibarea utilizarii constructorului de copiere si operatorului de atribuire

```
class Singleton {
   …
protected:
   …
   void operator=(Singleton&) = delete;
   Singleton(const Singleton&) =  delete;
   …
}
```

C++ 2011

- C++ 2011 include si constructorul de mutare

- din manual (12.8):

“3 A non-template constructor for class X is a move constructor if its first parameter is of type X&&, **`const`** X&&, **`volatile`** X&&, or **`const volatile`** X&&, and either there are no other parameters or else all other parameters have default arguments (8.3.6).

(continuare pe slide-ul urmator)

C++ 2011

[Example: Y::Y(Y&&) is a move constructor.

```
struct Y {
  Y(const Y&);
  Y(Y&&);
};
extern Y f(int);
Y d(f(1)); // calls Y(Y&&)
Y e = d; // calls Y(const Y&)
```

— end example]”

- Ar trebui ascuns si constructorul de mutare?

C++ 2011:

- Nu intotdeauna
- Din manual (12.8):

“10 If the definition of a class X does not explicitly declare a move constructor, one will be implicitly declared as defaulted if and only if

— X does not have a user-declared copy constructor,

— X does not have a user-declared copy assignment operator,

— X does not have a user-declared move assignment operator,

— X does not have a user-declared destructor, and

— the move constructor would not be implicitly defined as deleted.”

Instanta unica dinamica 1/2

```
template <typename Data>
class Singleton {
public:
  static Singleton* instance() {
    if (uniqueInstance == 0) {
      uniqueInstance = new Singleton();
  }
    return uniqueInstance;
  }
  // metode care opereaza peste instanta
  unica
  Data getData() { return data; }
  void setData(Data x) { data = x; }
```

Instanta unica dinamica 2/2

```
protected:
   Data data;
   Singleton()   { }
   // void operator=(Singleton&);
   // Singleton(const Singleton&);
   // Singleton(Singleton&)
private:
   static Singleton<Data>* uniqueInstance;
};
```

Nu mai e necesar de ascuns

Pointer la instanta unica

Demo

```
Singleton<int>* s1 = Singleton<int>::instance();
 s1->setData(47);
 cout << s1->getData() << endl;  // 47
 Singleton<int>* s2 = Singleton<int>::instance();
 s2->setData(9);
 cout << s1->getData() << endl;  // 9
 cout << s2->getData() << endl;  // 9
```

Diferenta dintre pointer si referinta 1/2

- urmatoarele instructiuni se executa, indiferent cum declaram constructorul de copiere si/sau operatorul de atribuire

```
Singleton<int>* s4 = s2;
s4->setData(23);
cout << s4->getData() << endl;
cout << s2->getData() << endl;

s4 = s1;
s4->setData(43);
cout << s4->getData() << endl;
cout << s2->getData() << endl;
```
de ce?

Diferenta dintre pointer si referinta 2/2

- dar urmatoarea instructiune nu se compileaza daca se decomenteaza constructorul de copiere

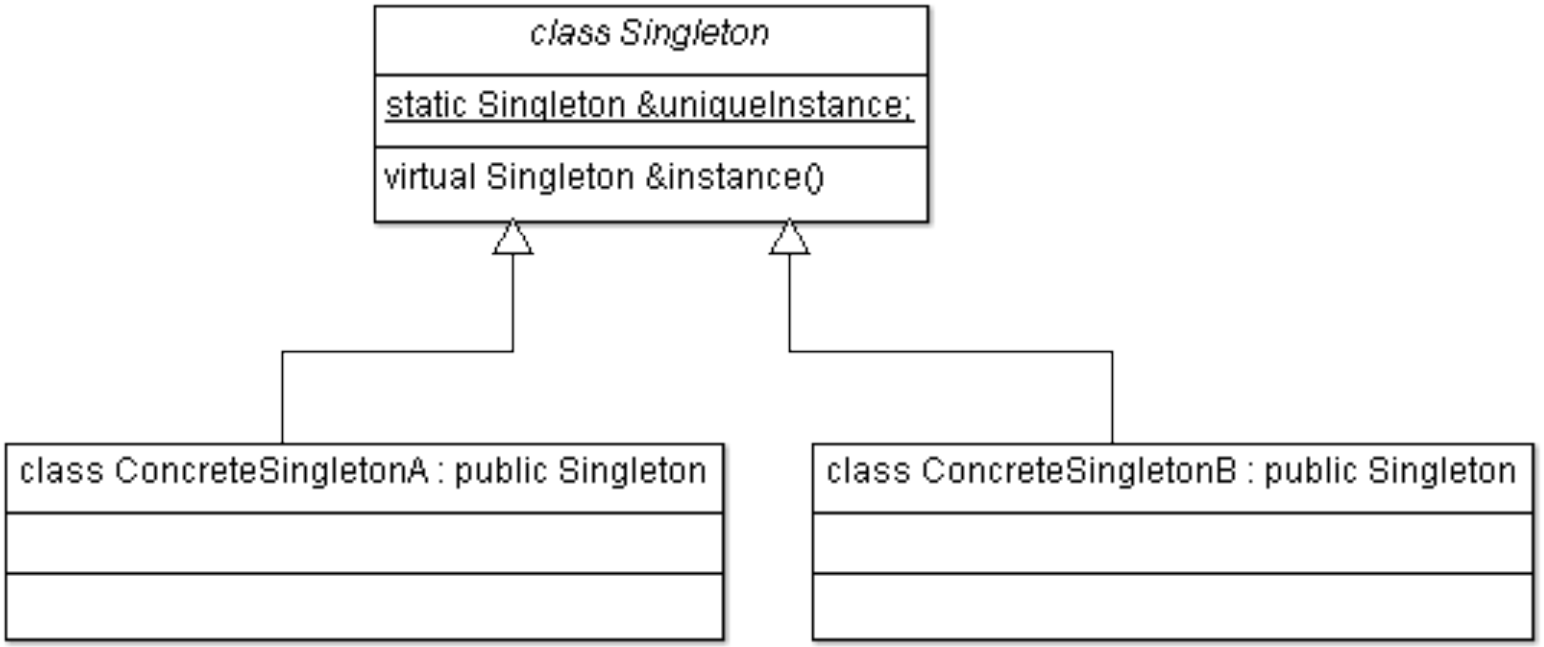
```
Singleton s5 = (*s2);
```

- si urmatoarea instructiune nu se compileaza daca se decomenteaza si operatorul de atribuire

```
s5 = *s1;
```

Demo

Clase singleton derivate



- pot fi probleme la crearea instantelor a claselor concrete din ierarhie => repositoriu de clase Singleton

Repozitoriu de clase singleton 1/3

```
class Singleton {
public:
  static void register(const char* name,
                       Singleton*);
  static Singleton* instance();
protected:
  static Singleton* lookup(const char* name);
private:
  static Singleton* uniqueInstance;
  static List<NameSingletonPair>* registry;
};
```

Repozitoriu de clase singleton 2/3

- metoda instance cauta in registru adresa instantei unice pentru o clasa concreta din ierarhie

```
Singleton* Singleton::instance () {
 if (uniqueInstance == 0) {
  const char* singletonName = getenv("SINGLETON");
   // furnizata la incarcarea aplicatiei
  uniqueInstance = lookup(singletonName);
   // lookup intoarce 0 daca nu gaseste
 }
 return uniqueInstance;
}
```

Repozitoriu de clase singleton 3/3

- o clasa singleton concreta din ierarhie trebuie sa inregistreze in registru adresa instantei unice

```
ConcreteSingletonA::Singleton() {
   // ...
   Singleton::register("ConcreteSingletonA",
                       this);
}
```

- in fisierul cu implementarea trebuie sa avem

```
static ConcreteSingletonA theSingletonA;
```

POO

Builder

(prezentare bazata pe GoF)

Intentie

- Separa constructia unui obiect complex de reprezentarile sale astfel incat procesul de constructie poate crea diferite reprezentari

- clasificare: creational

Motivatie

Default color

Red

Default color

- RTF

{\rtf1\ansi\deff0

{\colortbl;\red0\green0\blue0;\red255\green0\blue0;}

Default color\line

\cf2

Red\line

\cf1

Default color

}

Motivatie

- LaTeX

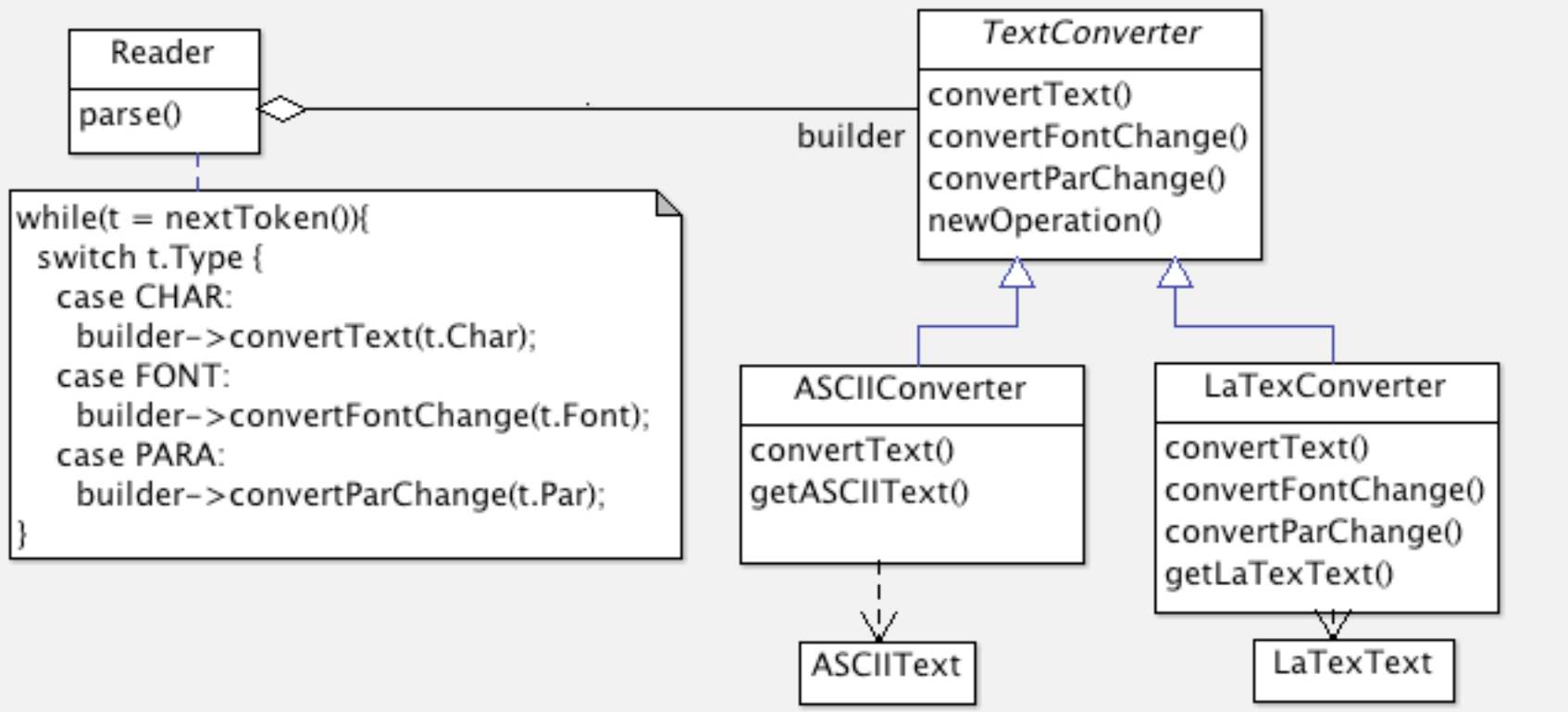
```
\rm Default color\\
\color{red}Red\\
\color{black}Default color
```

- ASCII

```
Default color\nRed\nDefault color
```

- …

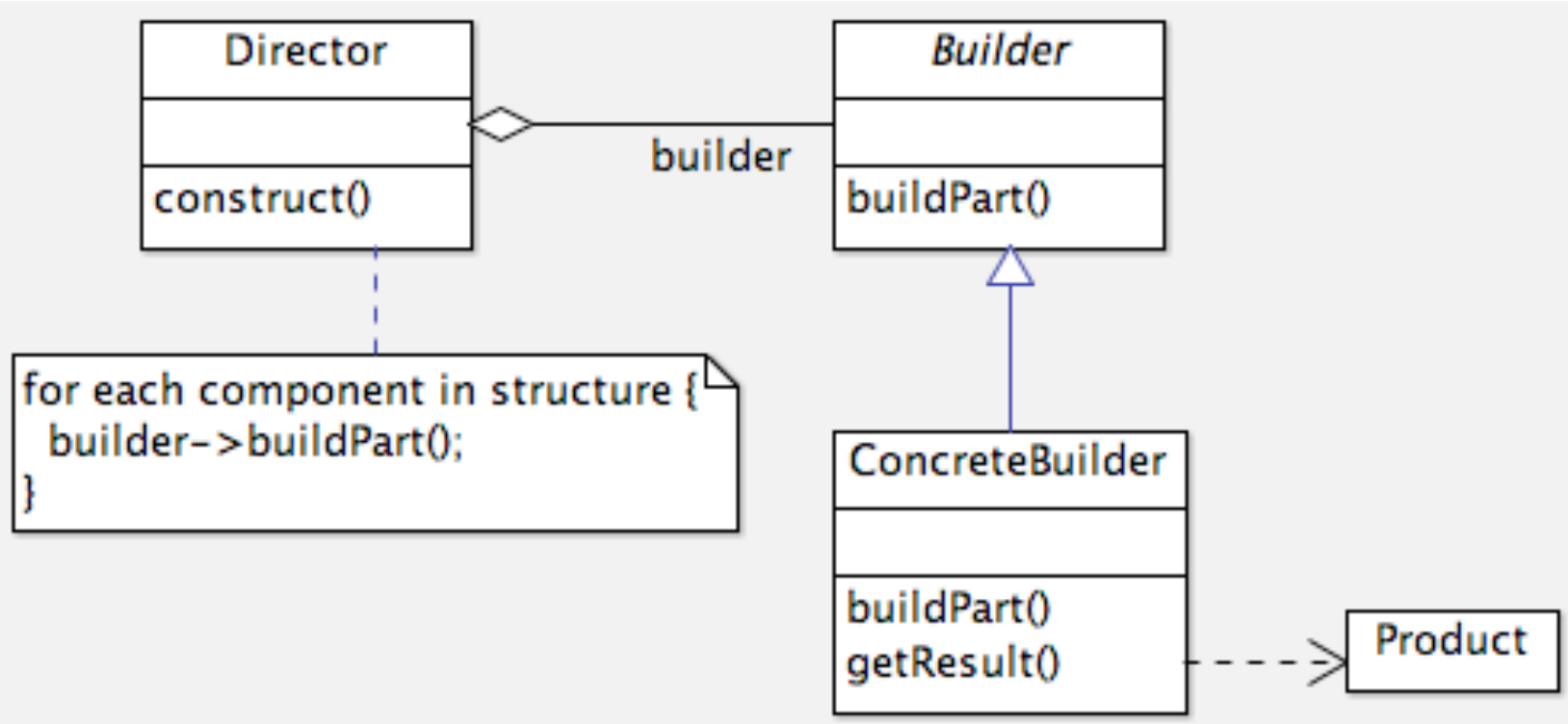
Motivatie


Reader
parse()
builder
TextConverter
convertText()
convertFontChange()
convertParChange()
newOperation()
while(t = nextToken()){
switch t.Type {
case CHAR:
builder->convertText(t.Char);
case FONT:
builder->convertFontChange(t.Font);
case PARA:
builder->convertParChange(t.Par);
}
ASCIIConverter
convertText()
getASCIIText()
LaTexConverter
convertText()
convertFontChange()
convertParChange()
getLaTexText()
ASCIIText
LaTexText

Aplicabilitate

- algoritmul de creare a unui obiect complex trebuie sa fie independent de componente si asamblarea lor
- constructia trebuie sa permita mai multe reprezentari

Structura


Director
construct()
builder
Builder
buildPart()
for each component in structure {
builder->buildPart();
}
ConcreteBuilder
buildPart()
getResult()
Product

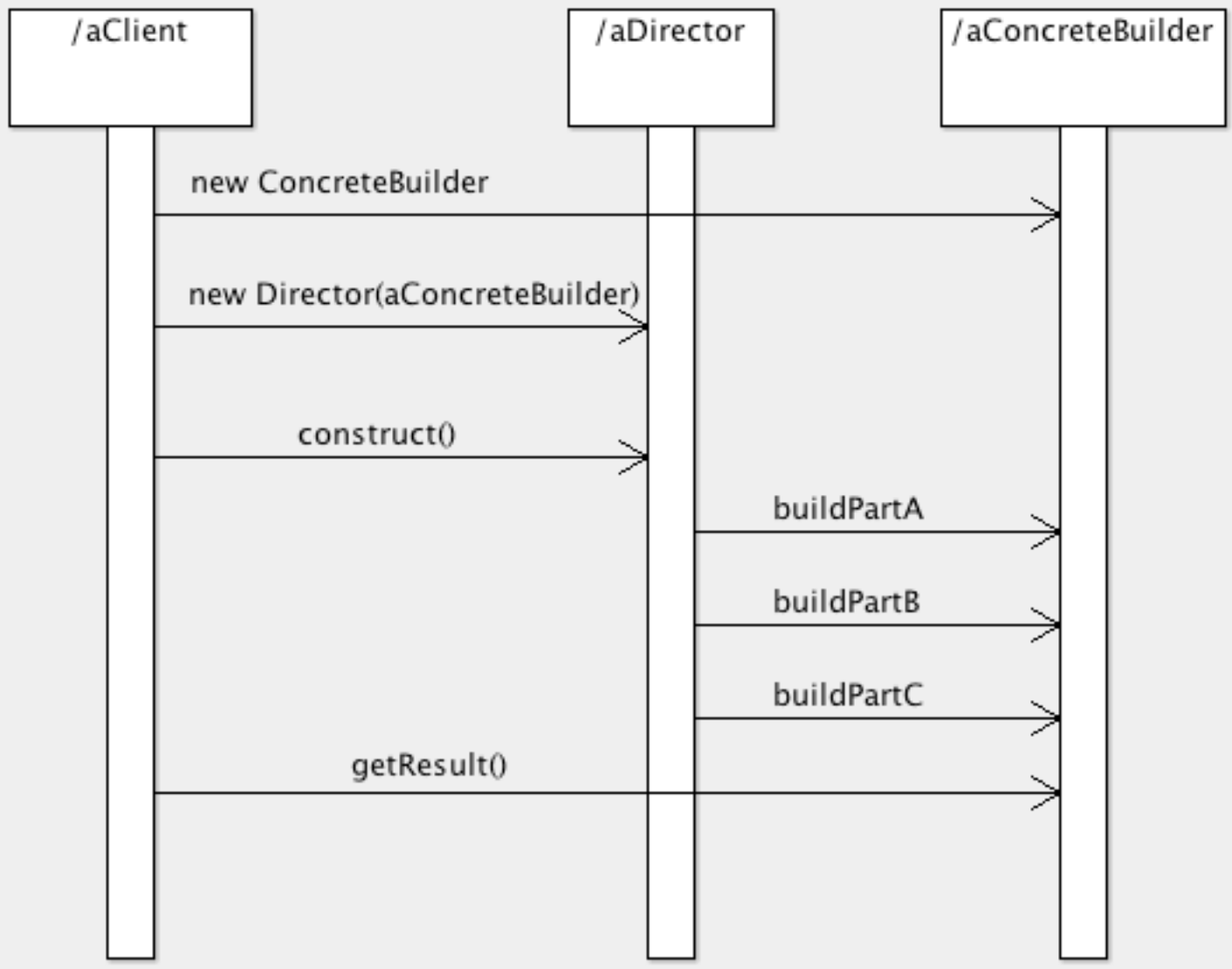
Participanti

- Builder
  - defineste o interfata abstracta pentru crearea componentelor necesare pentru a construi un obiect Product
- ConcreteBuilder
  - implementeaza interfata Builder, construind si asambland componentele
  - defineste si pastreaza o “urma” a reprezentarii create
  - defineste o interfata pentru regasirea produsului
- Director
  - construieste obiectul complex
- Product
  - reprezinta obiectul complex care se construieste
  - include clasele ce definesc partile constituiente.

Colaborari

- clientul creeaza un obiect Director si-l configureaza cu un obiect Builder adecvat
- obiectul Director notifica obiectul Builder ori de cate ori o componenta trebuie construita
- obiectul Builder proceseaza cererile primite de la obiectul Director si adauga componentele
- clientul “preia” produsul de la obiectul Builder

Diagrama de colaborare



Consecinte

- Lasa libertatea de a varia reprezentarea interna a produsului
  - obiectul Builder fornizeaza obiectului Director o interfata pentru constructia produsului
  - interfata ii perminte obiectului Builder sa ascunde reprezentarea interna
- Izoleaza codul destinat construirii produsului de reprezentare
  - clientii nu cunosc nimic despre reprezentare
- Permite sa ai controlul asupra procesului de constructie
  - produsul este construit componenta cu componenta, prin intermediul obiectului Builder

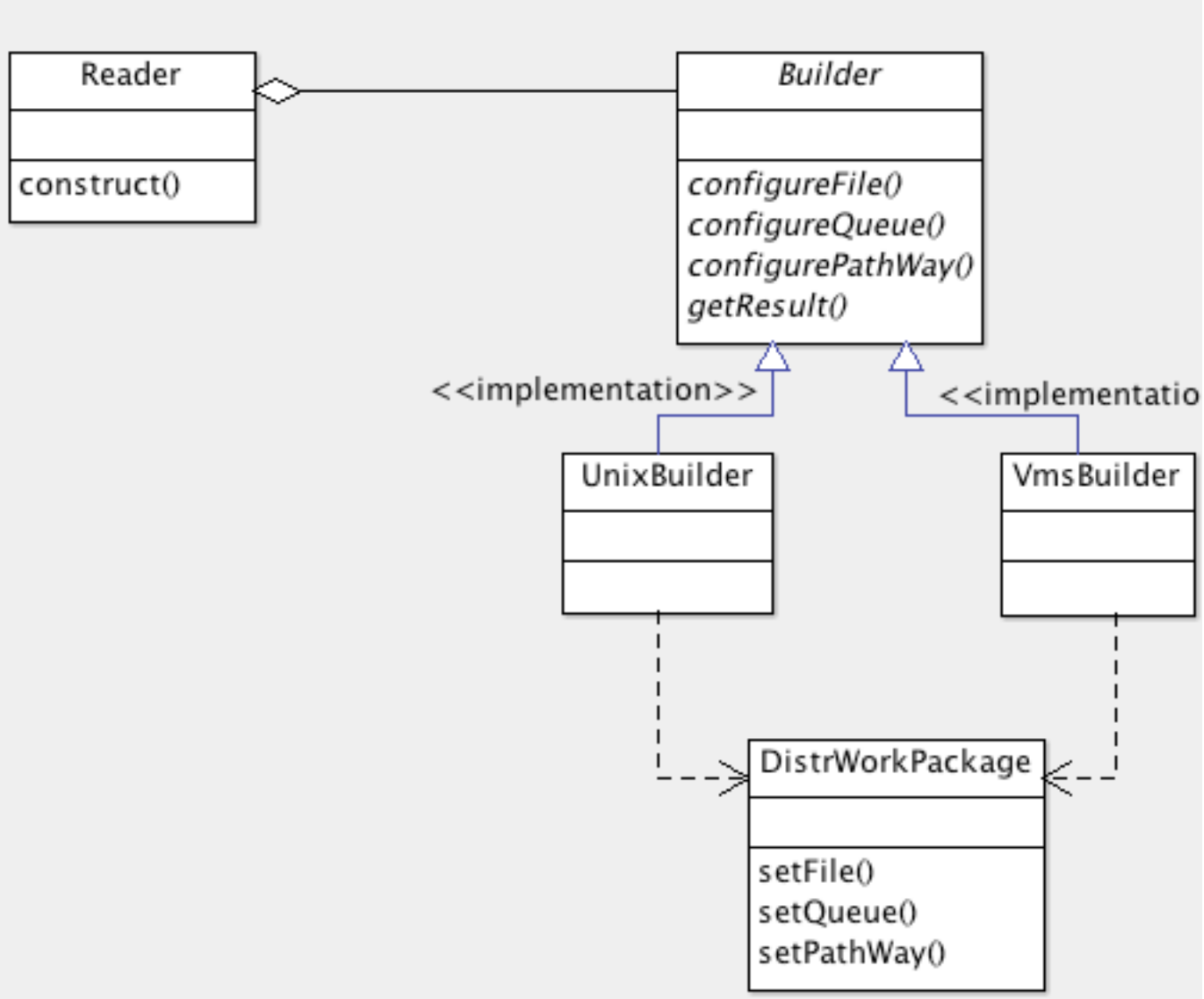
Implementare

- vom discuta exemplul “distributed work packages” din cartea “Design Patterns Explained Simply”

(https://sourcemaking.com/design_patterns/builder/cpp/1)

- problema consta in a defini o interfata abstracta pentru pachetele de lucru distribuite ce sa fie persistenta si independenta de platforma
- aceasta presupune implementari specifice platformelor pentru fisier (file), cozi de prioritate (queue), cai de executie concurenta (concurrent pathways)

Distributed Work Package Diagram



Produsul (DistrWorkPackage)

```
class DistrWorkPackage
{
  public:
    DistrWorkPackage(char *type);
    void setFile(char *f, char *v);
    void setQueue(char *q, char *v);
    void setPathway(char *p, char *v);
    const char *getState();
 private:
    char _desc[200], _temp[80];
};
```

Interfata Builder

```
class Builder
{
  public:
    virtual void configureFile(char*) = 0;
    virtual void configureQueue(char*) = 0;
    virtual void configurePathway(char*) = 0;
    DistrWorkPackage *getResult()
    {
        return _result;
    }
  protected:
    DistrWorkPackage *_result;
};
```

Un *Builder* concret: UnixBuilder

```
class UnixBuilder : public Builder  {
  public:
    UnixBuilder()    {
        _result = new DistrWorkPackage("Unix");
    }
    void configureFile(char *name)    {
        _result->setFile("flatFile", name);
    }
    void configureQueue(char *queue)    {
        _result->setQueue("FIFO", queue);
    }
    void configurePathway(char *type)    {
        _result->setPathway("thread", type);
    }
};
```

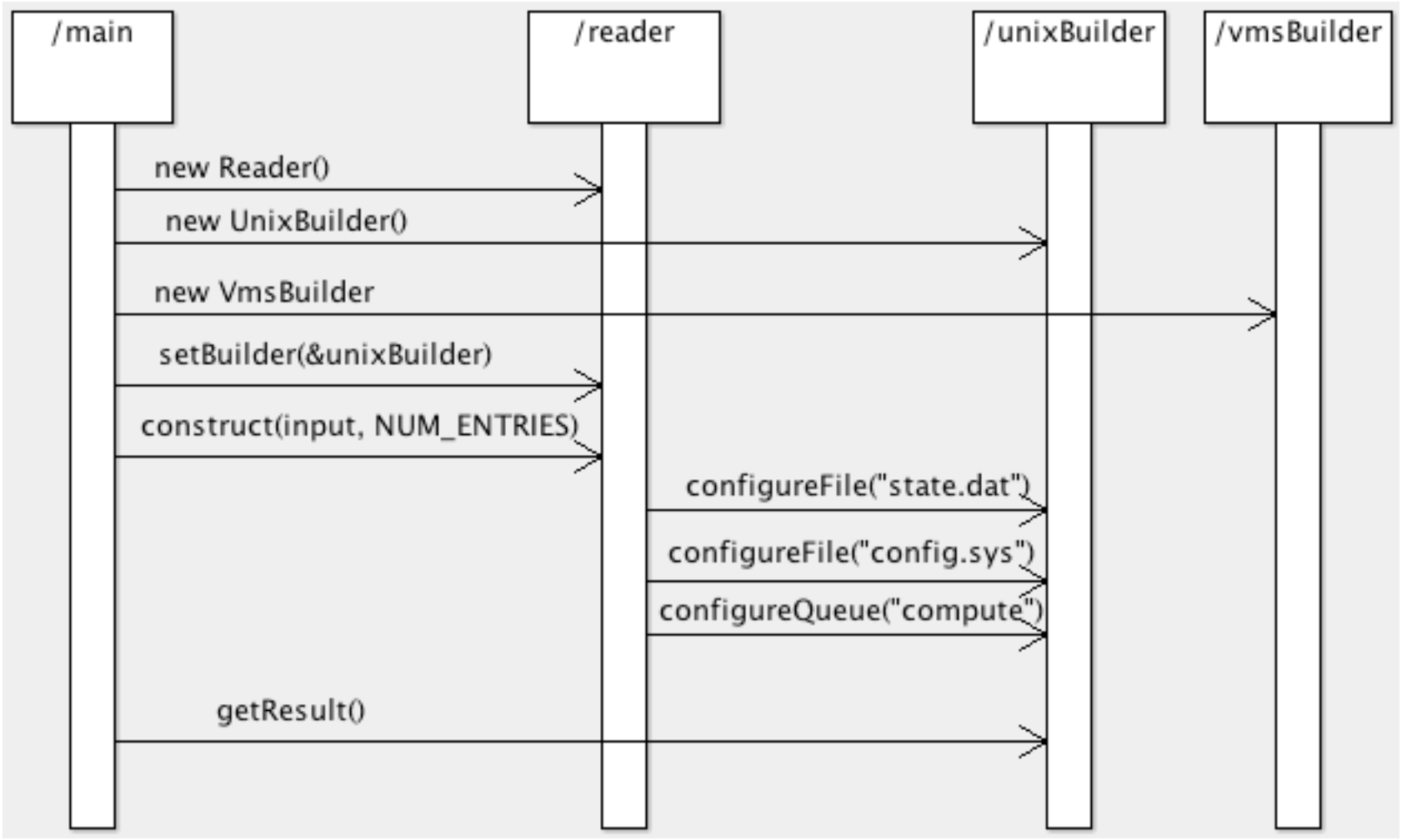
Clasa Director (Reader)

```
class Reader
{
  public:
    void setBuilder(Builder *b)
    {
        _builder = b;
    }
    void construct(PersistenceAttribute[], int);
  private:
    Builder *_builder;
};
```

metoda construct()

```
void Reader::construct(PersistenceAttribute list[], int num)
{
  for (int i = 0; i < num; i++)
    if (list[i].type == File)
      _builder->configureFile(list[i].value);
    else if (list[i].type == Queue)
      _builder->configureQueue(list[i].value);
    else if (list[i].type == Pathway)
      _builder->configurePathway(list[i].value);
}
```

Demo – diagrama de colaborare



Demo - cod

```
int main()
{
  UnixBuilder unixBuilder;
  VmsBuilder vmsBuilder;
  Reader reader;

  reader.setBuilder(&unixBuilder);
  reader.construct(input, NUM_ENTRIES);
  cout << unixBuilder.getResult()->getState() << endl;

  reader.setBuilder(&vmsBuilder);
  reader.construct(input, NUM_ENTRIES);
  cout << vmsBuilder.getResult()->getState() << endl;
  return 0;
}
```

POO

Sablonul

Object Factory

Cuprins

- principiul inchis-deschis
- fabrica de obiecte (Abstract Object Factory)
  (prezentare bazata pe GoF)
- studii de caz:
  - *expression factory*

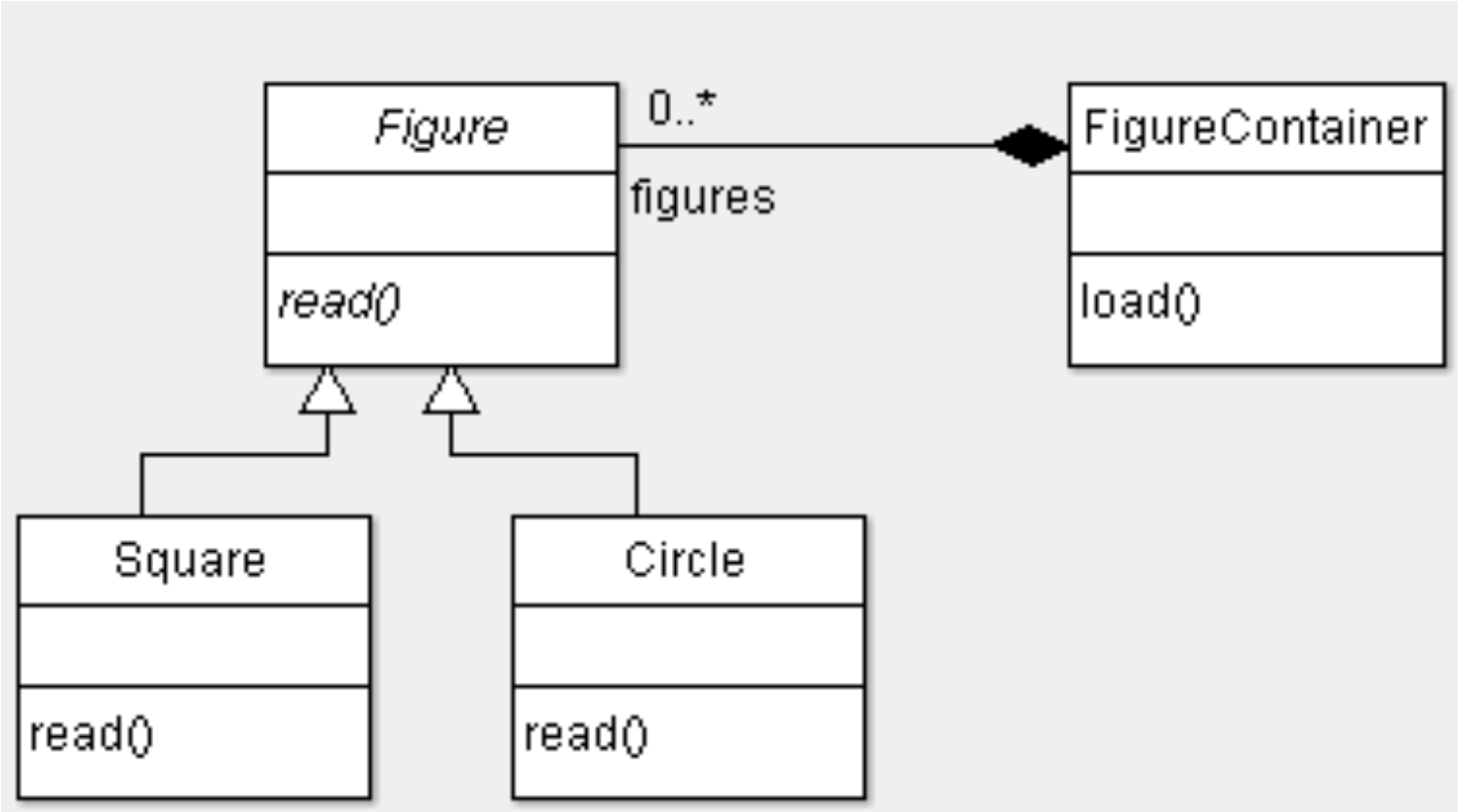
Principiul "inchis-deschis"

- "Entitatile software (module, clase, functii etc.) trebuie sa fie **deschise la extensii** si **inchise la modificare**" (Bertrand Meyer, 1988)

- "deschis la extensii" = comportarea modulului poate fi extinsa pentru a satisface noile cerinte

- "inchis la modificare" = nu este permisa modificarea codului sursa

Principiul "inchis-deschis" : exemplu



Principiul "inchis-deschis": neconformare

```
void FigureContainer::load(std::ifstream& inp)
{
     while (inp)
     {
          int tag;
          Figura* pfig;
          inp >> tag;
          switch (tag)
          {
             case SQUAREID:
                ...
             case CIRCLEID:
                ...
          }
     }
}
```

eticheta figura

citeste tipul figurii ce urmeaza a fi incarcate

pfig = new Square;
pfig.read(inp);

Square::read()

pfig = new Circle;
pfig.read(inp);

Circle::read()

adaugarea unui nou tip de figura presupune modificarea acestui cod

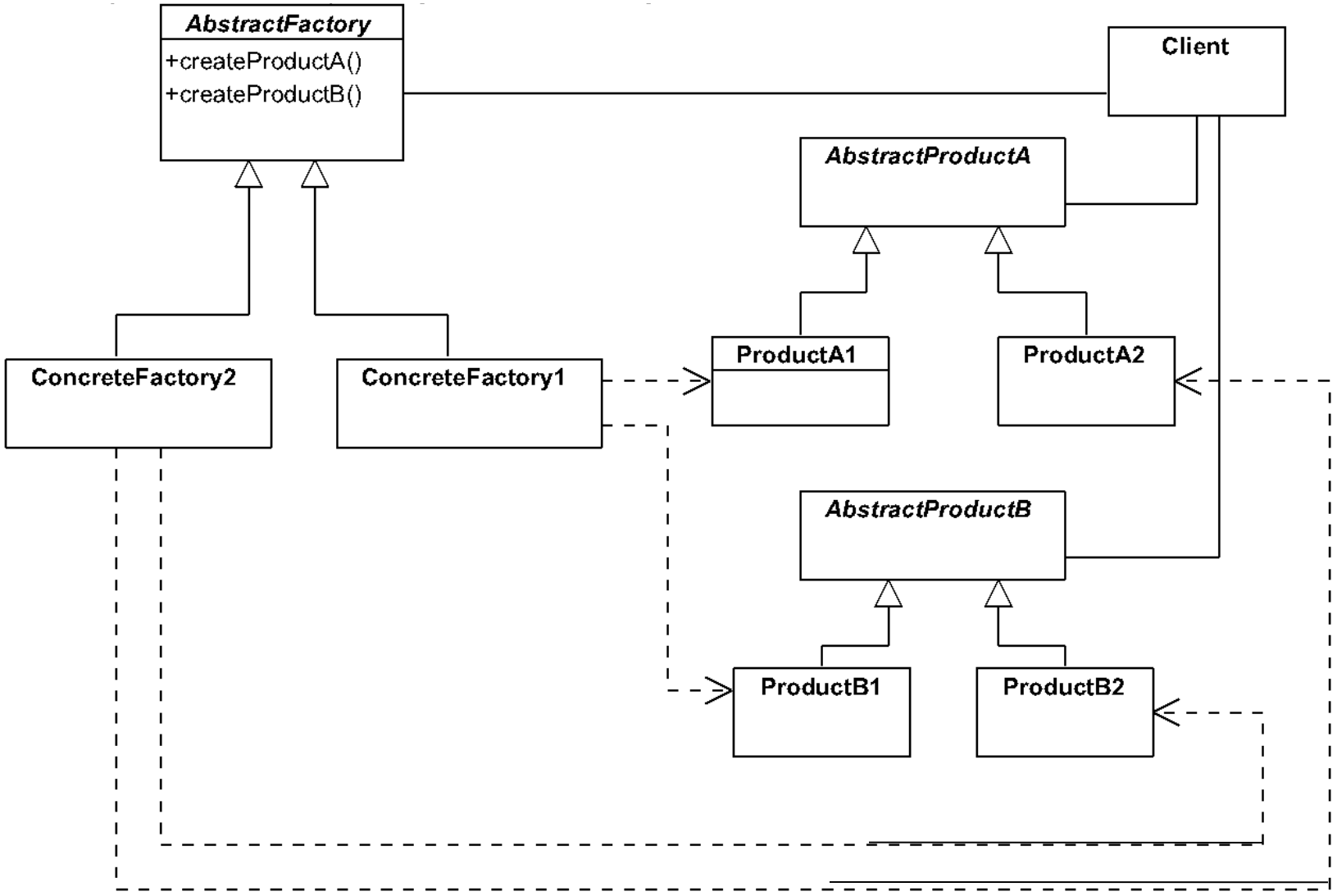
Principiul “inchis-deschis”

O posibila solutie:
fabrica de obiecte

Fabrica de obiecte (Abstract Factory)

- intentie
  - de a furniza o interfata pentru crearea unei familii de obiecte intercorelate sau dependente fara a specifica clasa lor concreta
- aplicabilitate
  - un sistem ar trebui sa fie independent de modul in care sunt create produsele, compuse sau reprezentate
  - un sistem ar urma sa fie configurat cu familii multiple de produse
  - o familie de obiecte intercorelate este proiectata pentru astfel ca obiectele sa fie utilizate impreuna
  - vrei sa furnizezi o biblioteca de produse si vrei sa fie accesibila numai interfata, nu si implementarea

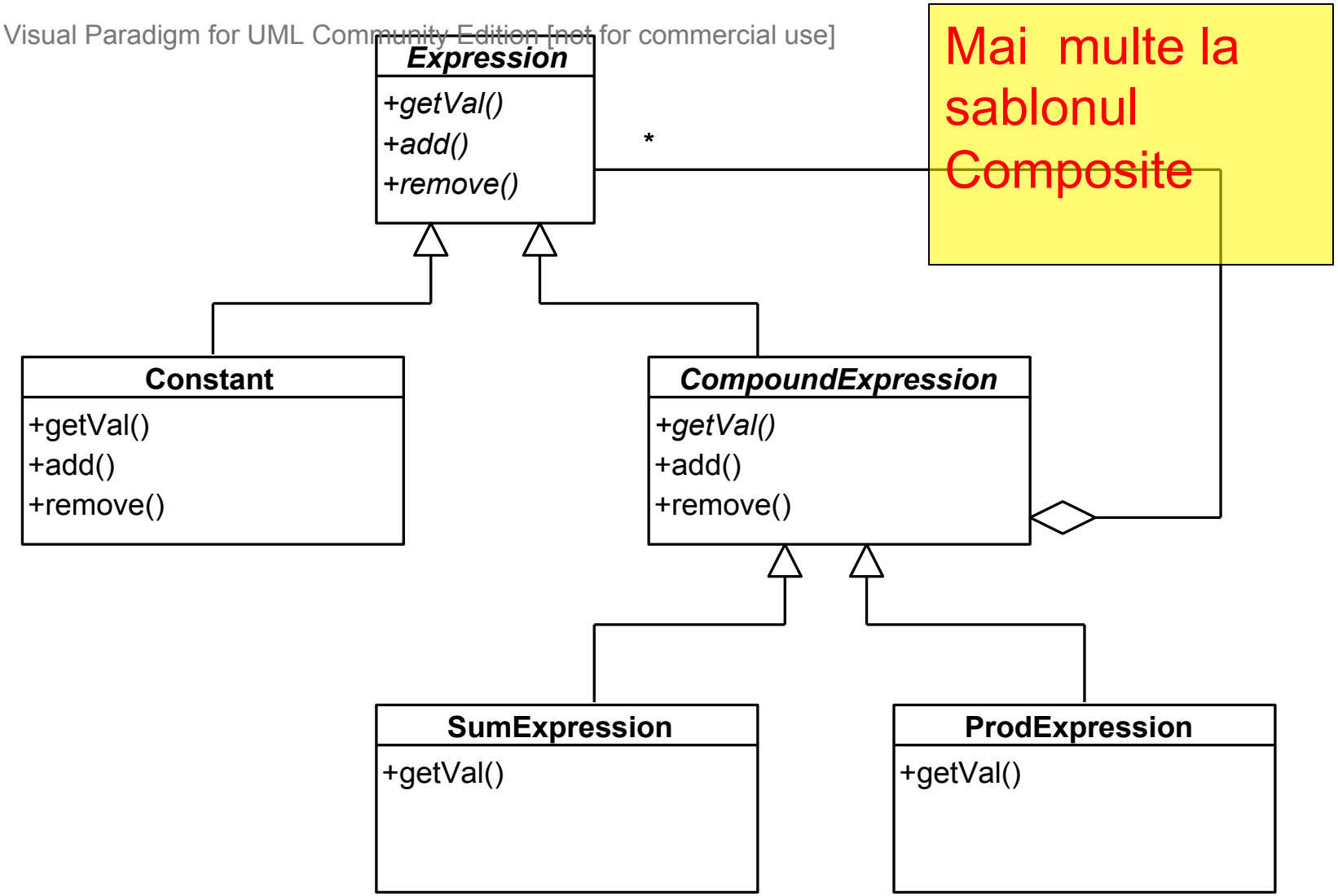
Fabrica de obiecte:: structura



Fabrica de obiecte

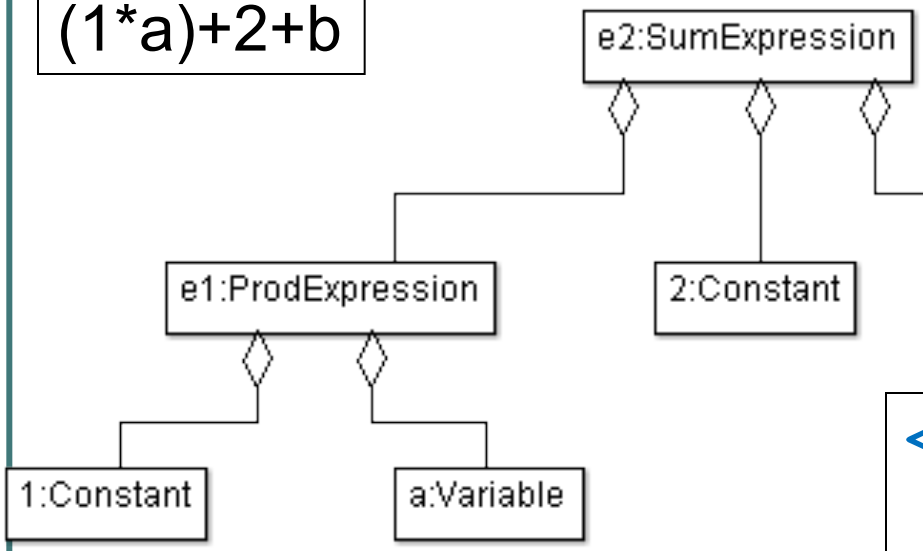
- colaborari
  - normal se creeaza o singura instanta
- Consecinte
  - izoleaza clasele concrete
  - simplifica schimbul familiei de produse
  - promoveaza consistenta printre produse
  - suporta noi timpul noi familii de produse usor
  - respecta principiul deschis/inchis
- implementare
  - se face pe baza studiului de caz “expression factory”

Expresii : : structura



Expressions: Problema (diagr. de obiecte)

(1*a)+2+b



serializare

deserializare

notatie XML

```
<sum>
  <prod>
    <constant> 1 </constant>
    <variable> a </variable>
  </prod>
  <constant> 2 </constant>
  <variable> b </variable>
</sum>
```

Expressions: Problema

- serializare
  - vizitator
- deserializare

sablonul Visitor va fi facut la cursurile urmatoare

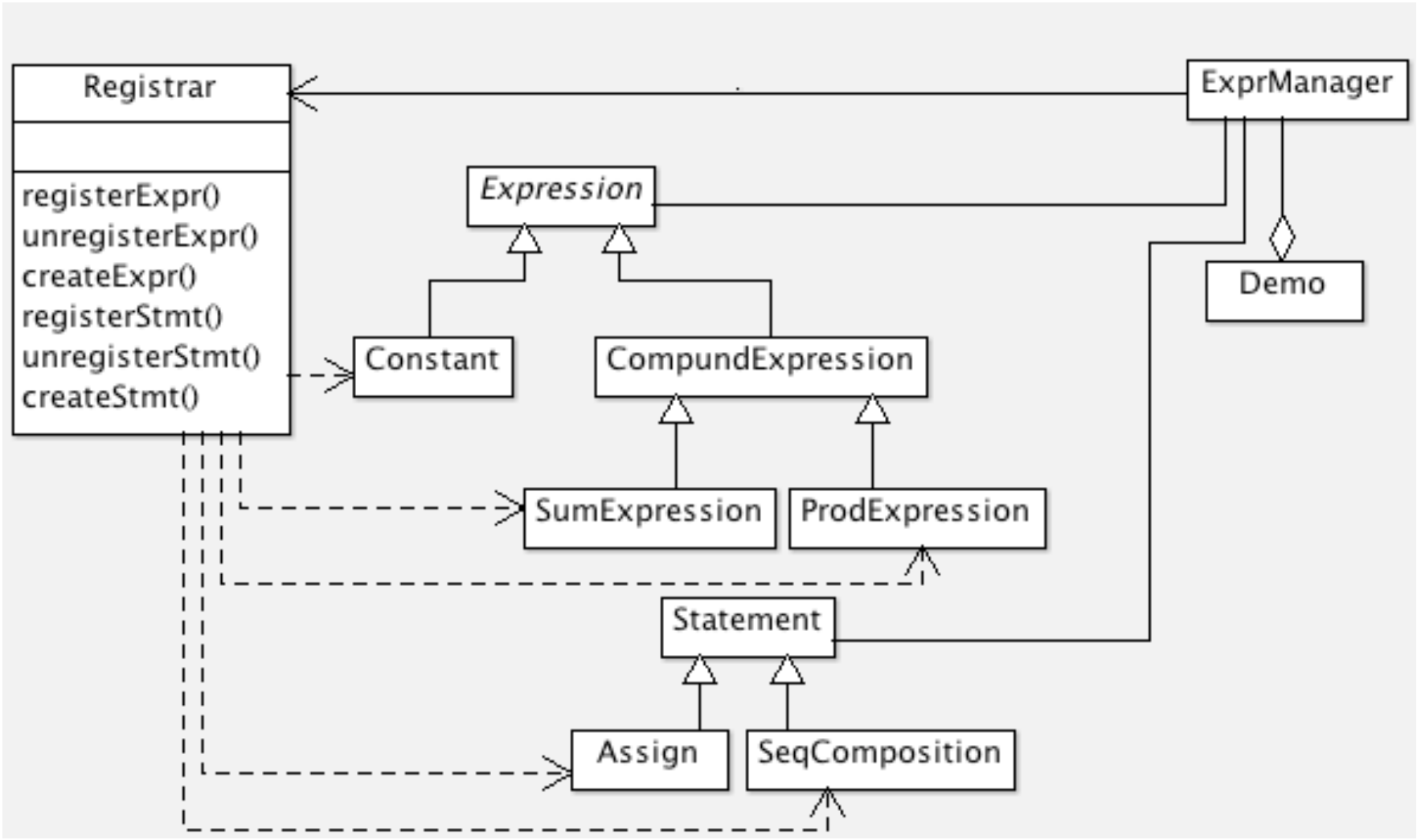
```
switch (tag)
   {
      case <sum>:
         ...
      case <prod>:
         ...
      case <constant>:
         ...
      case <variable>:
         ...
   }
```

se incalca principiul inchis-deschis

Solutia: object factory

- Corespondenta cu modelul standard
  - AbstractProductA = Expression
  - AbstractProductB = Statements (neimplementat inca, lasat ca exercitiu)
  - ConcreteFactory = Registrar (registru de expresii, instructiuni)
  - Client = ExprManager (responsabila cu deserializarea)

“Object factory” pentru expresii, instr.



Registru de clase (Registrar)

- este o clasa care sa gestioneze tipurile de expresii
  - inregistreaza un nou tip de expresie (apelata ori de cate ori se defineste o noua clasa derivata)
  - eliminarea unui tip de expresie inregistrat (stergerea unei clase derivate)
  - crearea de obiecte expresie
    - la nivel de implementare utilizam perechi

      (tag, createExprFn)
    - ... si functii delegat (vezi slide-ul urmator)
- se poate utiliza sablonul Singleton pentru a avea o singura fabrica (registru)

Functii delegat (callback)

- o functie **delegat** (**callback)** este o functie care nu este invocata explicit de programator; responsabilitatea apelarii este delegata altei functii care primeste ca parametru adresa functiei delegat
- Fabrica de obiecte utilizeaza functii delegat pentru crearea de obiecte: pentru fiecare tip este delegata functia carea creeaza obiecte de acel tip

- pentru “expression factory” declaram un alias pentru tipul functiilor de creare a obiectelor Expression

```
typedef Expression* ( *CreateExprFn )();
```

Registrar 1/3

```
class Registrar
{
  bool registerExpr(string tag,
                    CreateExprFn createExprFn )
  {
      return catalog.insert(
         std::pair<string, CreateExprFn>(
                        tag, createExprFn)
                             ).second;
  }
```

metoda responsabila cu inregistrarea unui nou tip de obiecte Expression

inserarea in catalog (un map)

a doua componenta a valorii intoarse de insert (inserare cu succes sau fara succes)

Registrar 2/3

```
void unregisterExpr(string tag)
   {
       catalog.erase(tag);
   }

Expression* createExpr(string tag)
   {
       map<string, CreateExprFn>::iterator i;
       i = catalog.find(tag);
       if ( i == catalog.end() )
             throw string("Unknown expression tag”);
       return (i->second)();
   }
```

metoda responsabila cu elimi-narea unui obiect tip Expression

metoda responsabila cu crearea de obiecte Expression

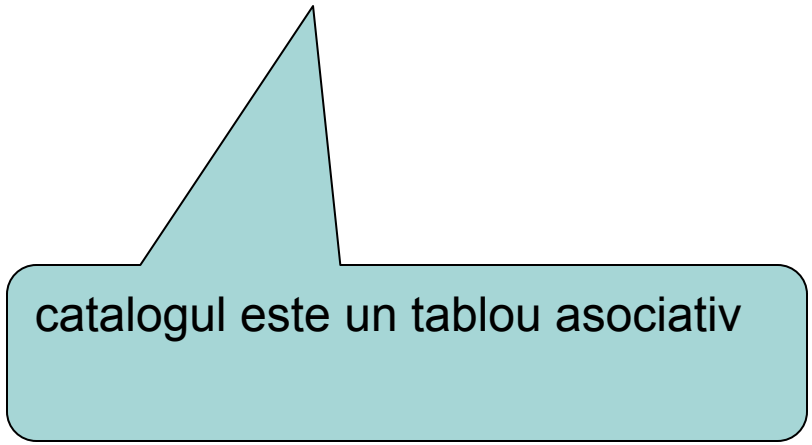
de fapt deleaga aceasta responsabilitate metodei care corespunde tipului dat ca parametru

Registrar 3/3

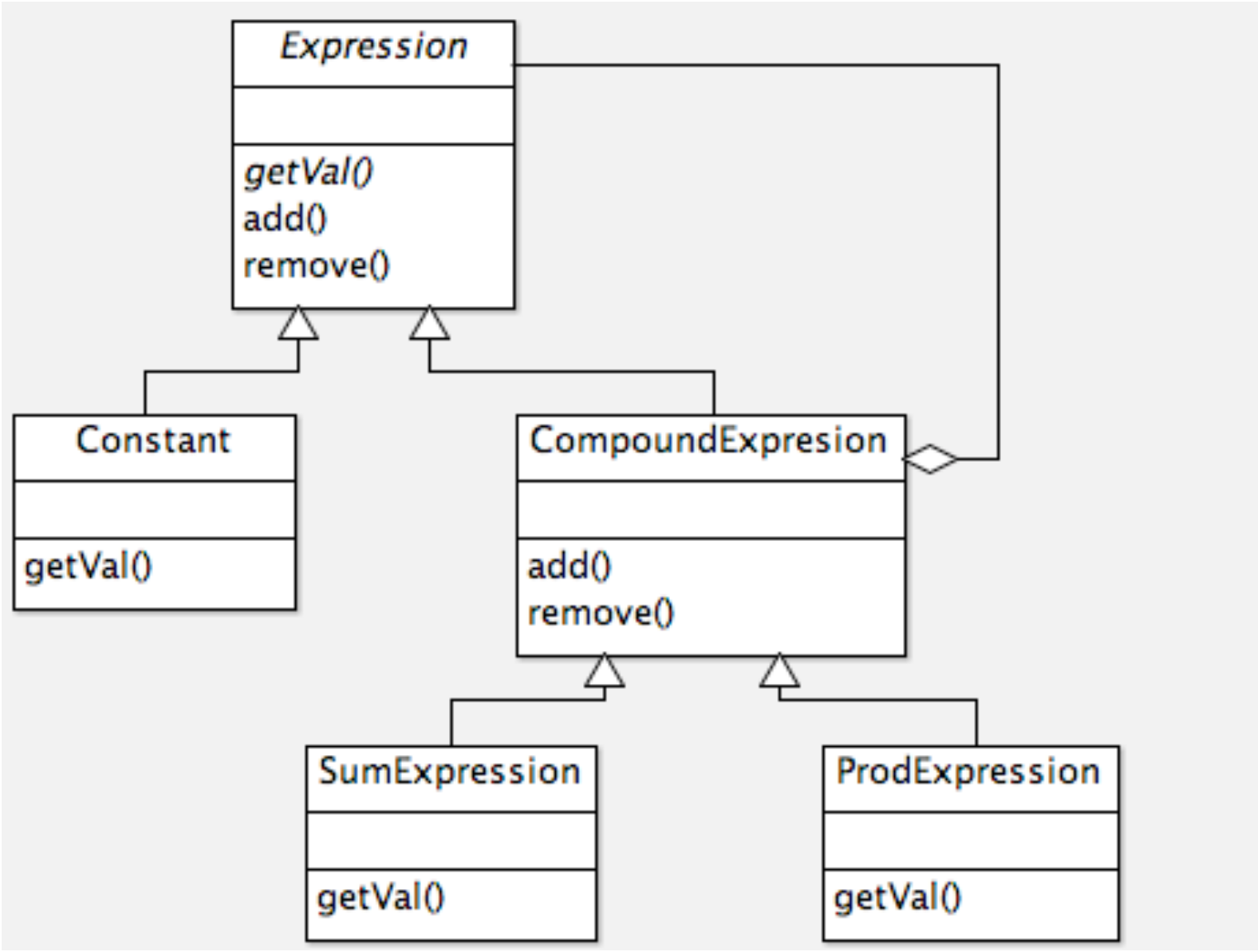
```
protected:

   map<string, CreateExprFn> catalog;

};
```



Produsele din familia Expression



expr-manager.h – functii de creare obiecte

```
Expression* createConstant() {
      return new Constant();
}

Expression* createVariable() {
      return new Variable();
}

Expression* createProd() {
      return new ProdExpression();
}
…
```

Clasa ExprManager - constructorul

```
class ExprManager {
public:
  ExprManager() {
    reg = new Registrar();
    reg->registerExpr("<constant>",
                      createConstant);
    reg->registerExpr("<variable>",
                      createVariable);
    reg->registerExpr("<prod>", createProd);
    reg->registerExpr("<sum>", createSum);
  }
```

Deserializarea (fabrica de obiecte din descrieri XML)

```
public:
  Expression* loadf(ifstream& f)
  {
      if (f.eof())
            throw "Unknown file.";
      string tag;
      f >> tag;
      return loadfRec(f, tag);
  }
protected:
  Registrar *reg;
```

Functia recursiva de creare obiecte 1/3

```
protected:
Expression* loadfRec(ifstream& f,
                     string tag)
{
  Expression* expr1 = reg->createExpr(tag);
  string endTag = tag.insert(1,"/");
  Expression* expr2;
```

creaza obiectul pentru nodul curent

calculeaza tagul de sfarsit

memoreaza expresiile componente, daca expr1 este compusa

... cazul obiectelor compuse

```
if (expr1->getCompoundExpression()) {
   if (f.eof())
     throw "File illformatted.";
   string nextTag;
   f >> nextTag;
   while (endTag != nextTag && !f.eof()) {
       expr2 = loadfRec(f, nextTag);
       expr1->add(expr2);
       f >> nextTag;
   }
}
```

citeste urmatorul tag

daca nu s-a ajuns la tagul de sfarsit, inseamna ca avem o noua componenta pe care o cream recursiv si o adaugam la expresia compusa

... cazul obiectelor elementare

```
    else {
      if (f.eof())
       throw "File illformatted.";
      expr1->loadInfo(f);
      if (f.eof())
        throw "File illformatted
      f >> tag;
    }
    return expr1;
  }
};
```

incarca informatia din nodul frunza

consuma tagul de sfarsit