Language Technology for Internet Telephony Service Creation

Charles Consel, Laurent Réveillère, et al.
Phoenix Research Group, INRIA–Futurs/LaBRI

Presenter: Lenin Singaravelu, Georgia Tech.

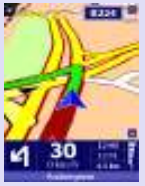
Internet Telephony Services

• Rapidly evolving with addition of new functionality such email, database access and web services

Service Creation








Issues in Service Development

- Software Intensive
- Robustness
- High Performance

- Interaction with low-level hardware
- Varying network types and capabilities
- Customer Needs

- Reuse Commodity services
- Safety, security, dependability

- Multimedia activities
- Multiple processing layers

Solution

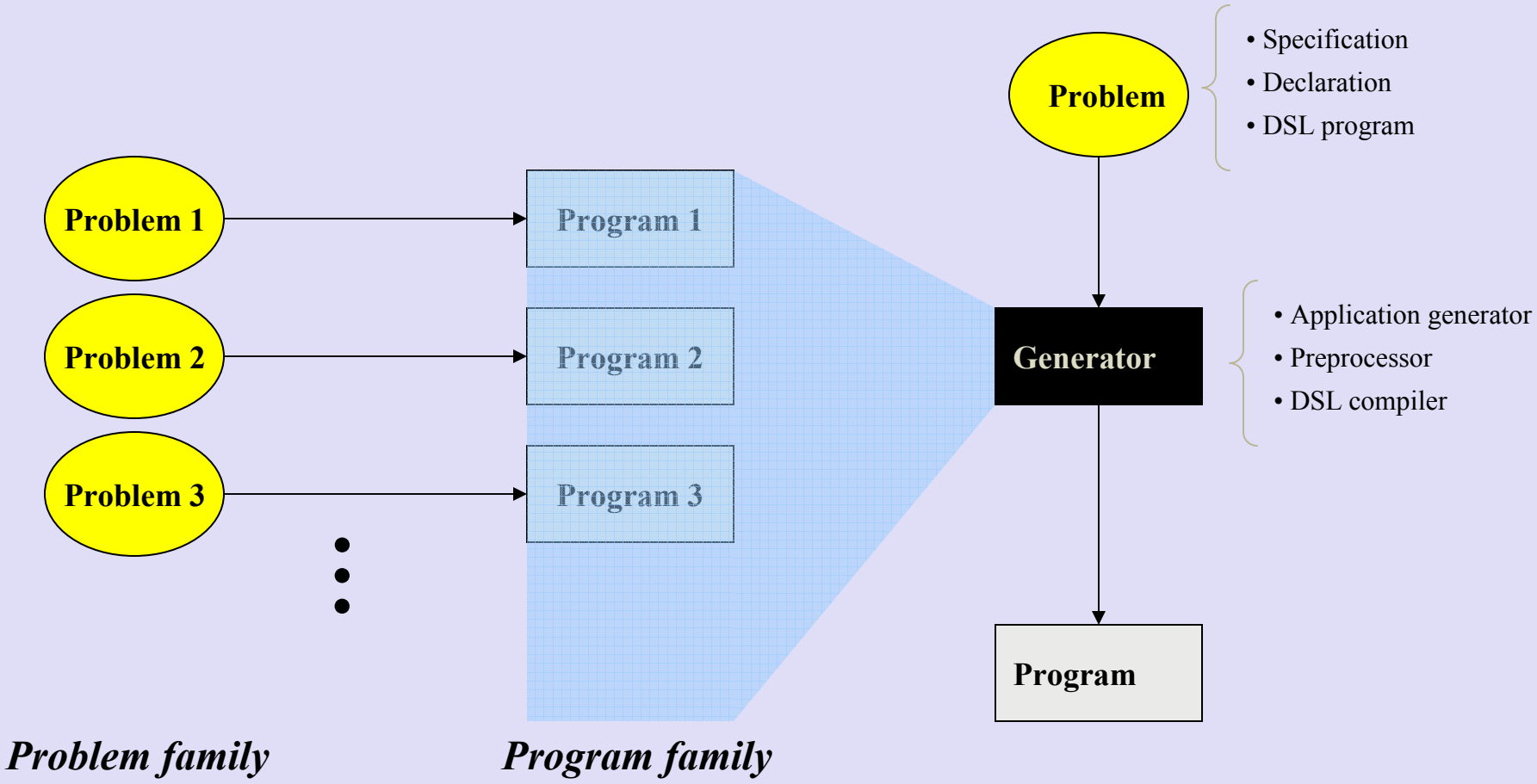
Programming Language ≡ Enabling Technology

- Software intensive → Language design
- Robustness → Program analysis
- High Performance → Program transformation

Talk Outline

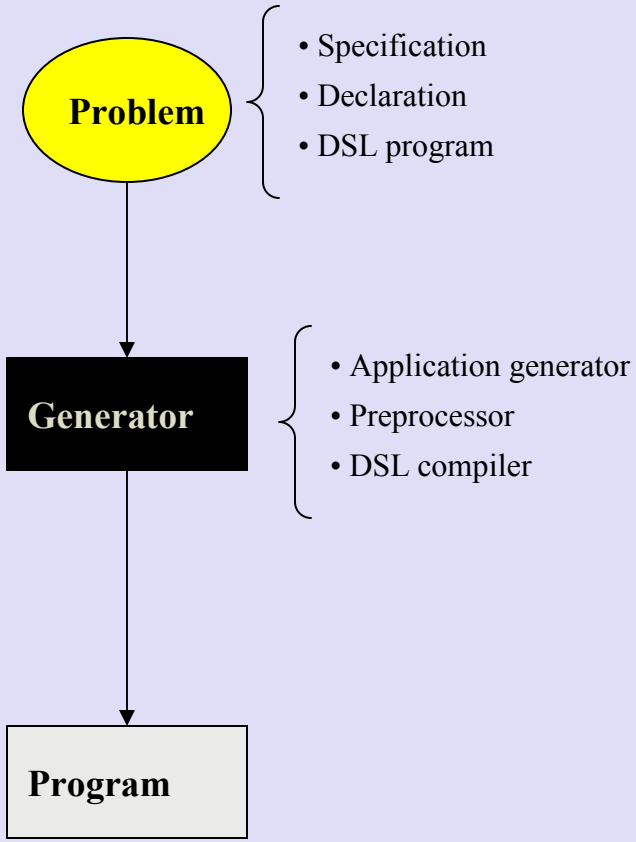
- Introduction to Domain Specific Languages (DSL)
- Overview of SIP
- SPL: A DSL for communication services
- Properties of SPL
- Summary

Domain-Specific Languages: The Basic Idea



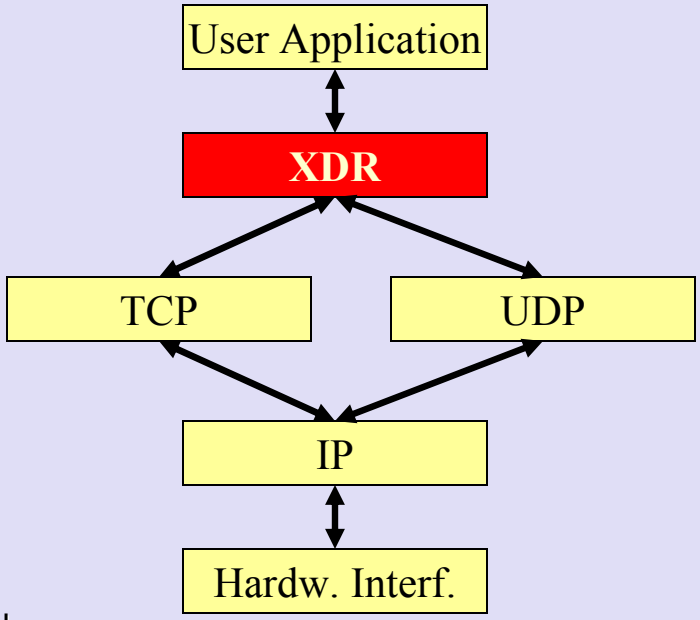
Domain-Specific Languages: Issues

- When to develop a DSL?
- What is the scope of the DSL?
- How to design for the DSL?
  - Key concept: program family
- How to implement the DSL?
  - Approach: stepwise methodology
    - Data coding/marshalling components
    - Device interface layers
- How to assess the benefits?
  - Key concept: program family



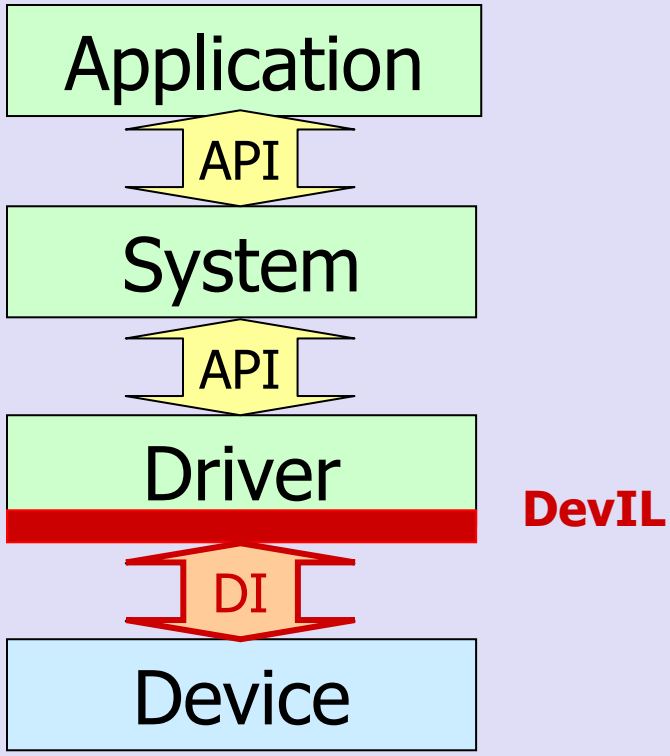
A Program Family with a DSL: Machine Independent Data Coding

- Commonalities: data traversal, type description…
- Variations: coding direction, size, format…



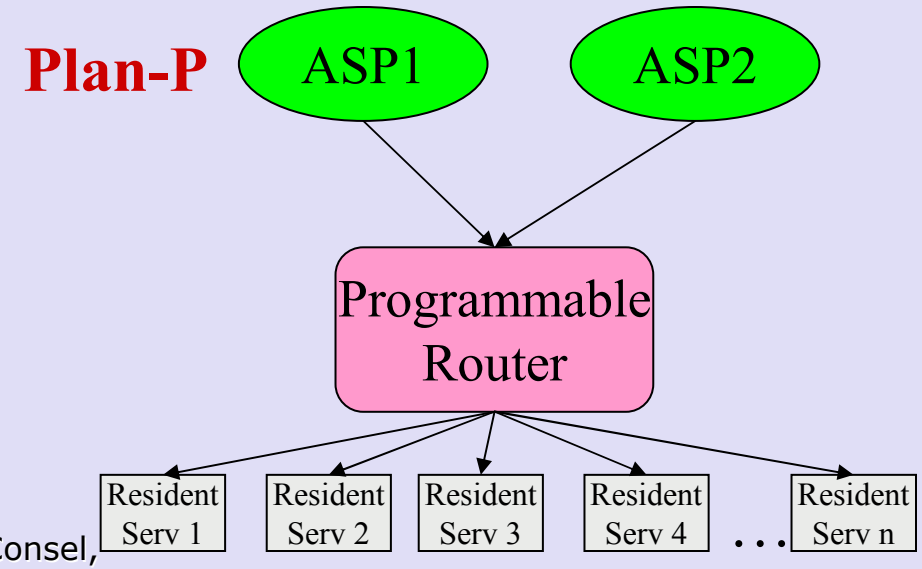
A Program Family with a DSL: Device Driver Interface

- Commonalities: API, bit operations...
- Variations: parameters, registers…



A Program Family with a DSL: Application-Specific Protocols

- Commonalities: API, packets operations
- Variations: routing policies, packet processing…



Program Family Characterization: A Key Step Towards DSL Design

- Nature of program family
  - Existing (Devil)
  - Virtual (≈ Plan-P)
  - Both (≈ Bossa)
- Scope of programs
  - Family of layers (Devil)
  - Family of components (Yacc)
  - Family of systems (Scripting language)
- Range of commonalities
  (size of program family captured)
- Scope of computations
  (kind of expressible computations)

Beyond Program Families

- Technical literature
- Documentation
- Domain experts
- Current and future requirements

Domain-Specific Languages: A (Conceptual) Definition

- Program family
- Domain-specific abstractions and notations

  Conciseness, readability
- Declarative (often)

  What to compute, not how to compute it
- Restricted/enriched semantics

  Making critical properties decidable

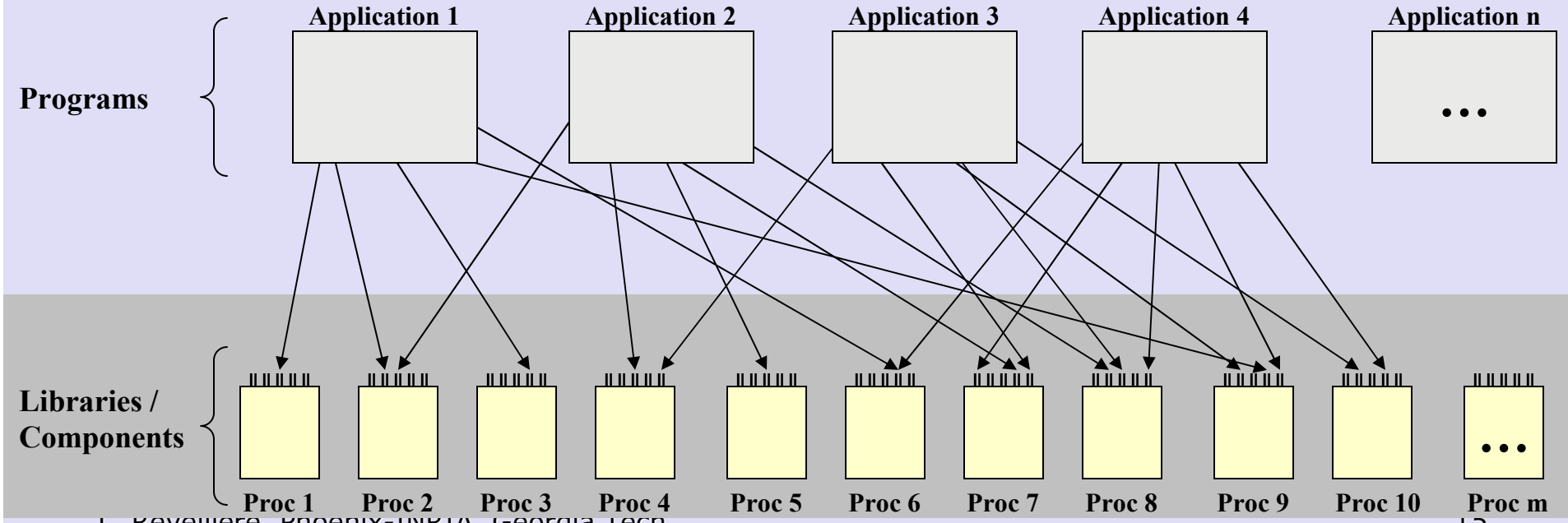
Approach to DSLs

- Resulting structure
  - Static semantics: interpreter/compiler
  - Dynamic semantics: Abstract machine
- Stepwise methodology:
  - Program family
  - Library/components
  - Abstract machine
  - DSL

Program Family: Libraries / Components

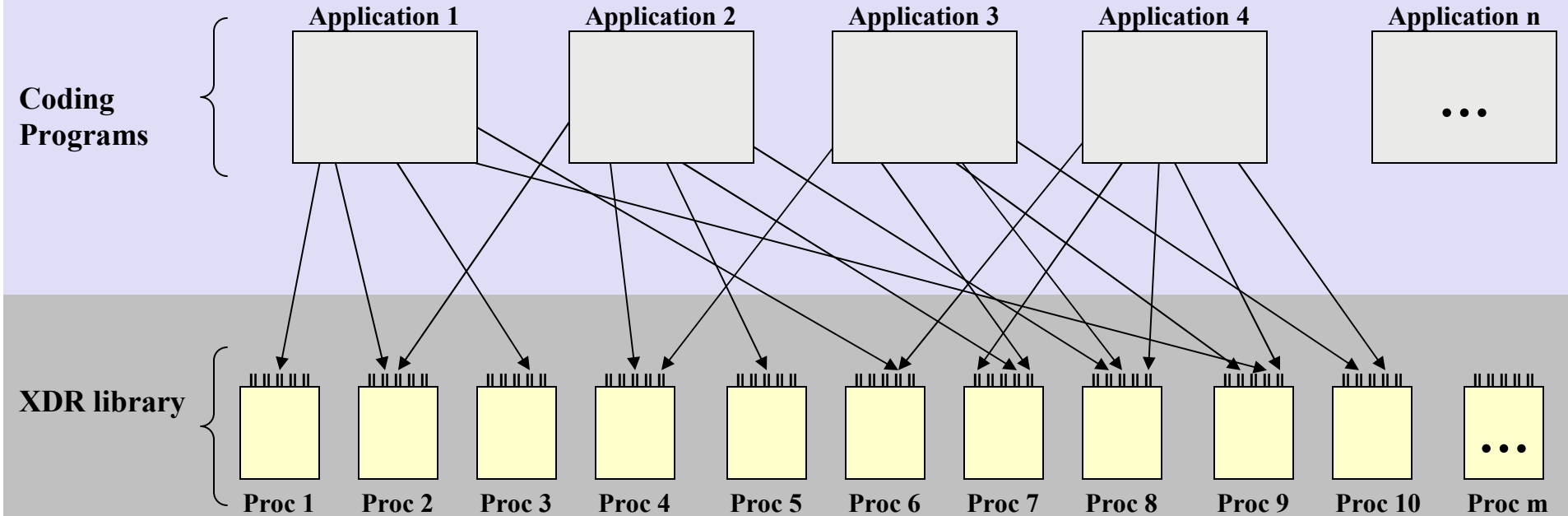
- Commonalities ⇨ Library entries
- Variations ⇨ Parameters

- Bloated code
  - Numerous cases



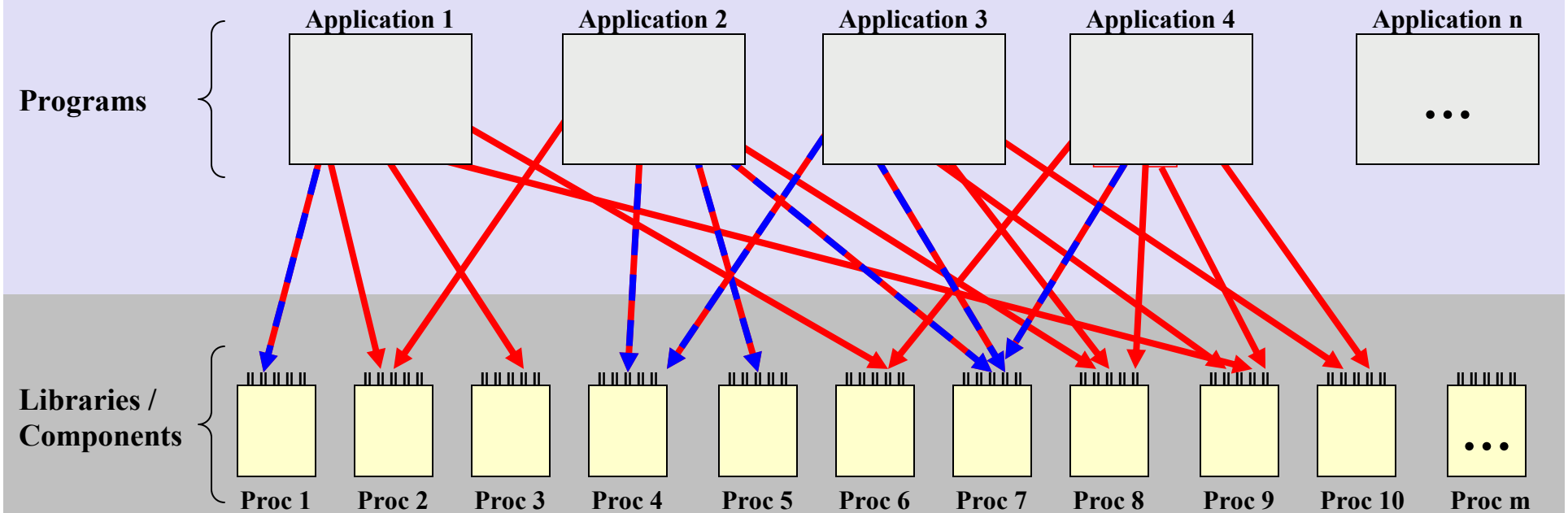
Coding Programs: XDR Library

`xdr_int`	Integer size
`xdr_long`	Coding direction
`XDR_PUTLONG`	Generic marshalling
`xdrmem_putlong`	Buffer write + overflow check
`htonl`	Byte ordering



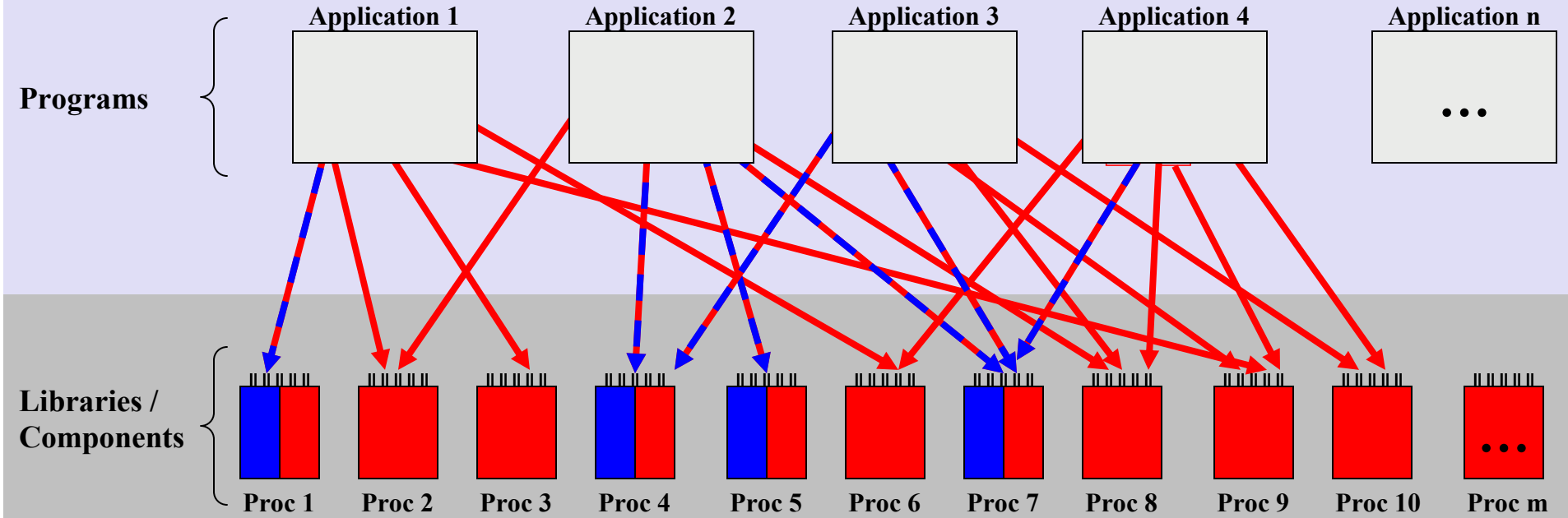
Program Family: Libraries / Components

- For a given set of problems : ***invariants***



Libraries/Components : *Need For Customization*

- For a given set of problems : ***invariants***
  - Optimize time (and/or)
  - Optimize space



XDR Library :

Need For Customization

`xdr_int`	Integer size
`xdr_long`	Coding direction
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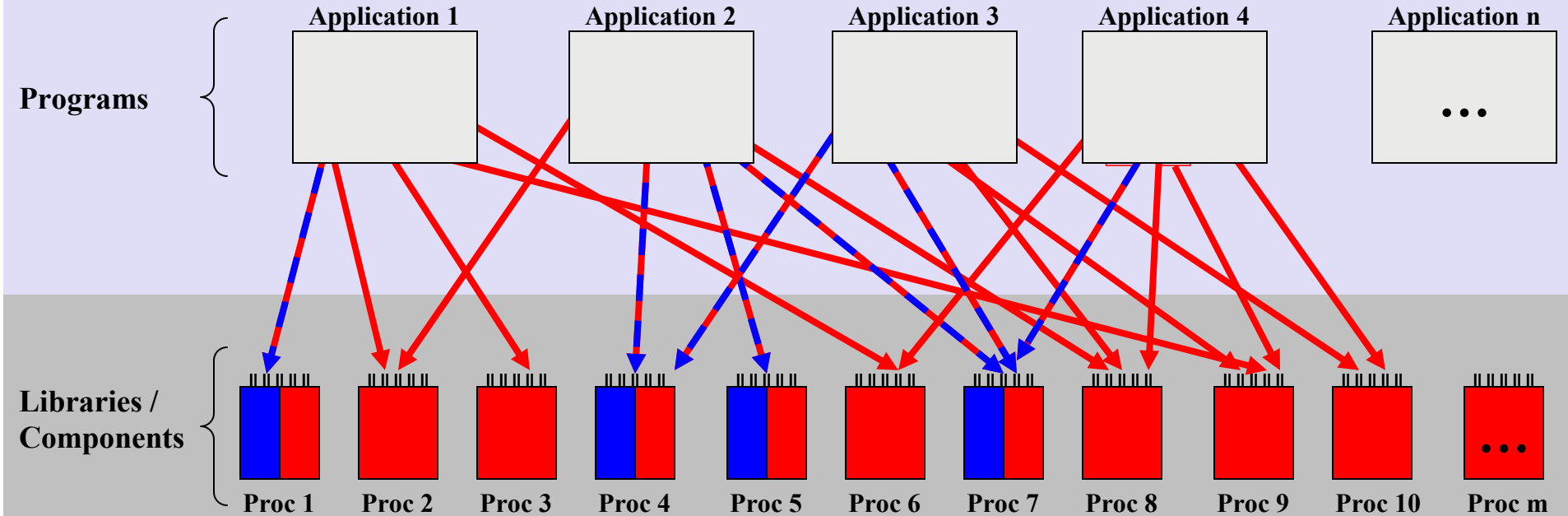
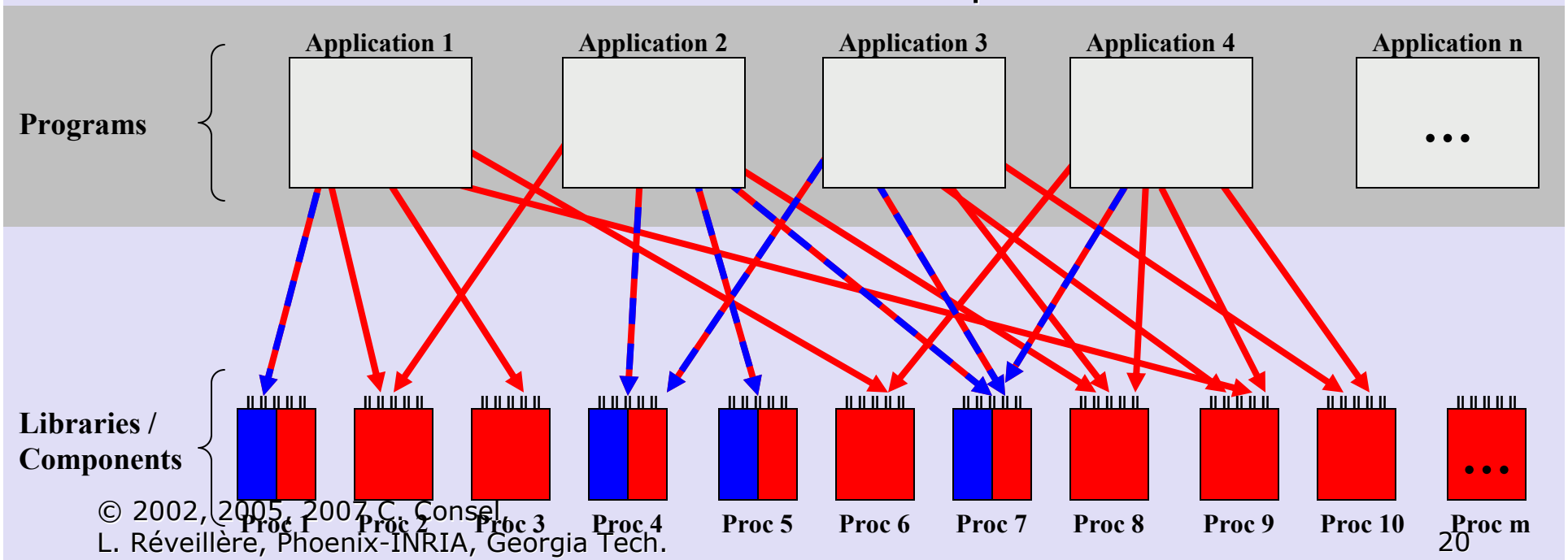
`htonl`	Byte ordering



Program Family: Applications

- General-purpose language
- Lack of software architecture

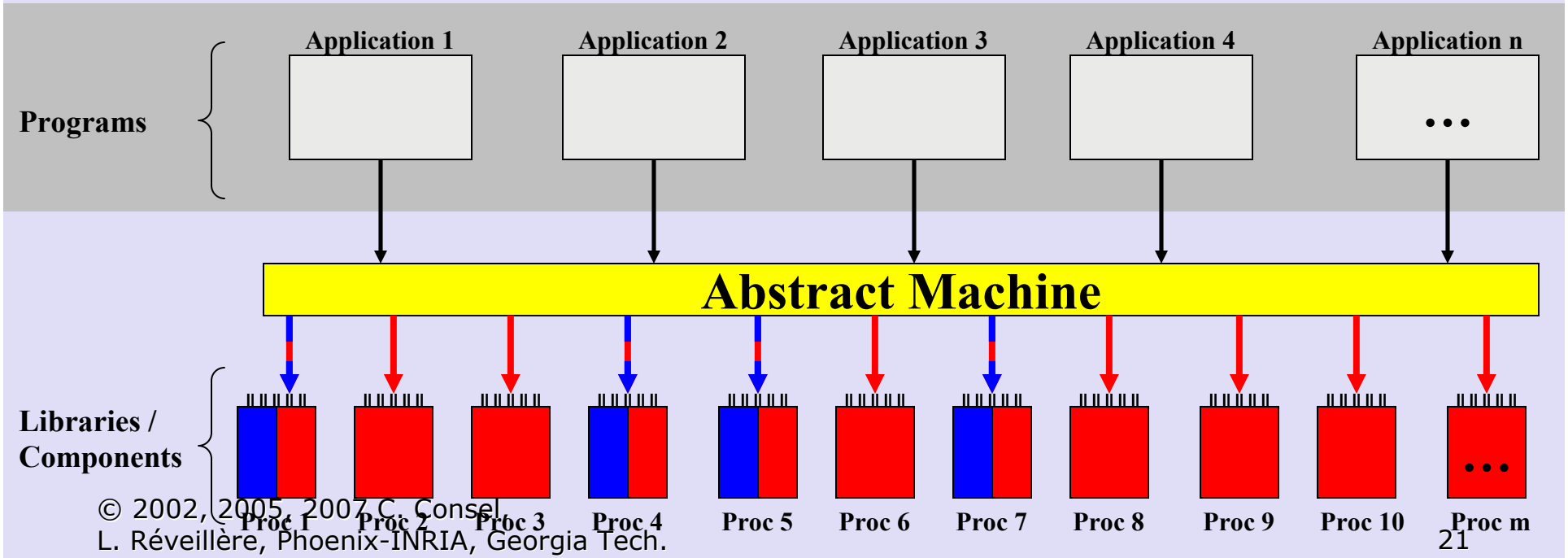
- Prologues/epilogues
  - Prepare invocations
  - Maintain state
  - Perform checks
- Results: complex, repetitive, expertise required



Applications: *Need for Abstract Machine* *(intermediate step)*

- Interface to libraries
- Explicit run-time model
  - State definition and operations
  - Dynamic checks
  - Operation encapsulation
  - Operation combination

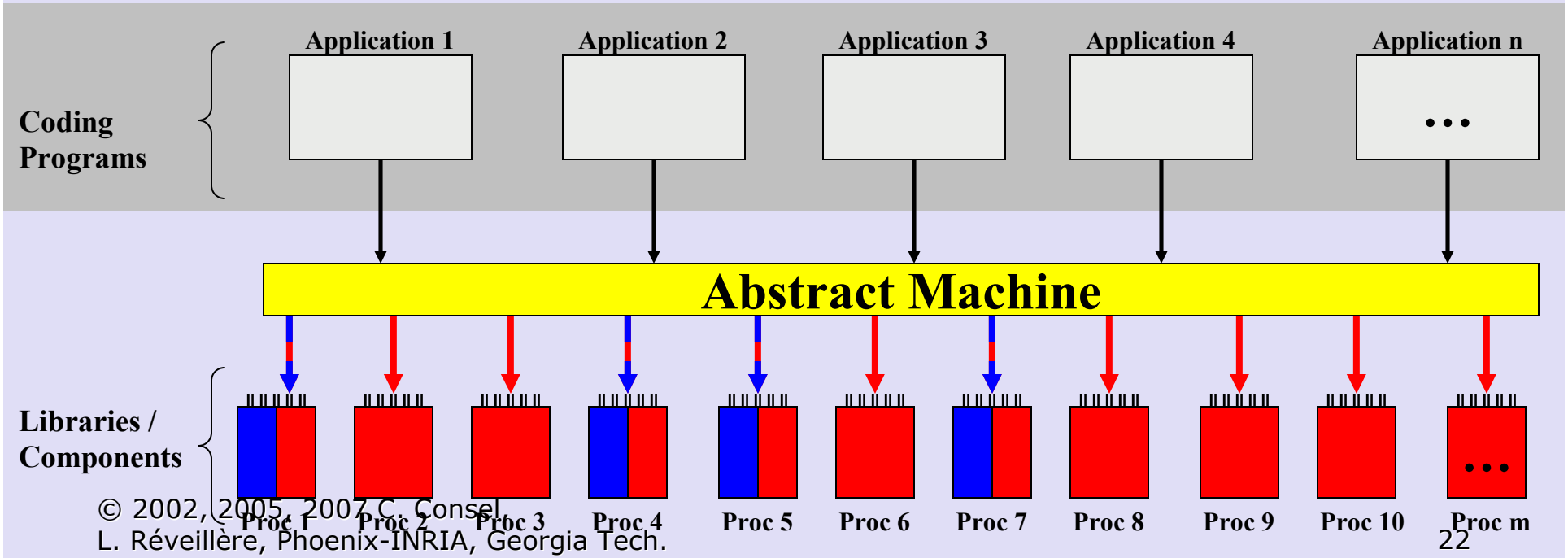
- More concise
- More usable
- More explicit expertise
- Abstraction layer



Coding Applications: *Need for Abstract Machine* *(intermediate step)*

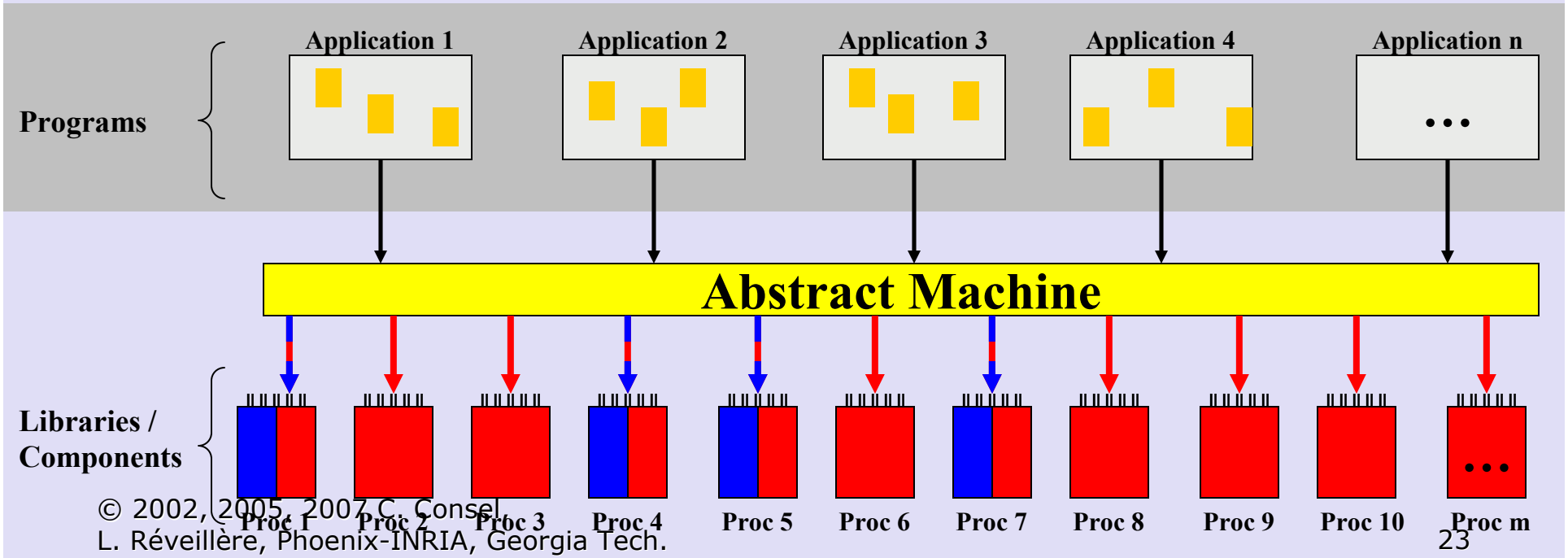
- More concise
- More usable
- More explicit expertise
- Abstraction layer

- **XDR** Data Coding Machine
  - Instruction set: XDR library
  - State: XDR structure
  - Parameterized instruction set



Program Family: Applications

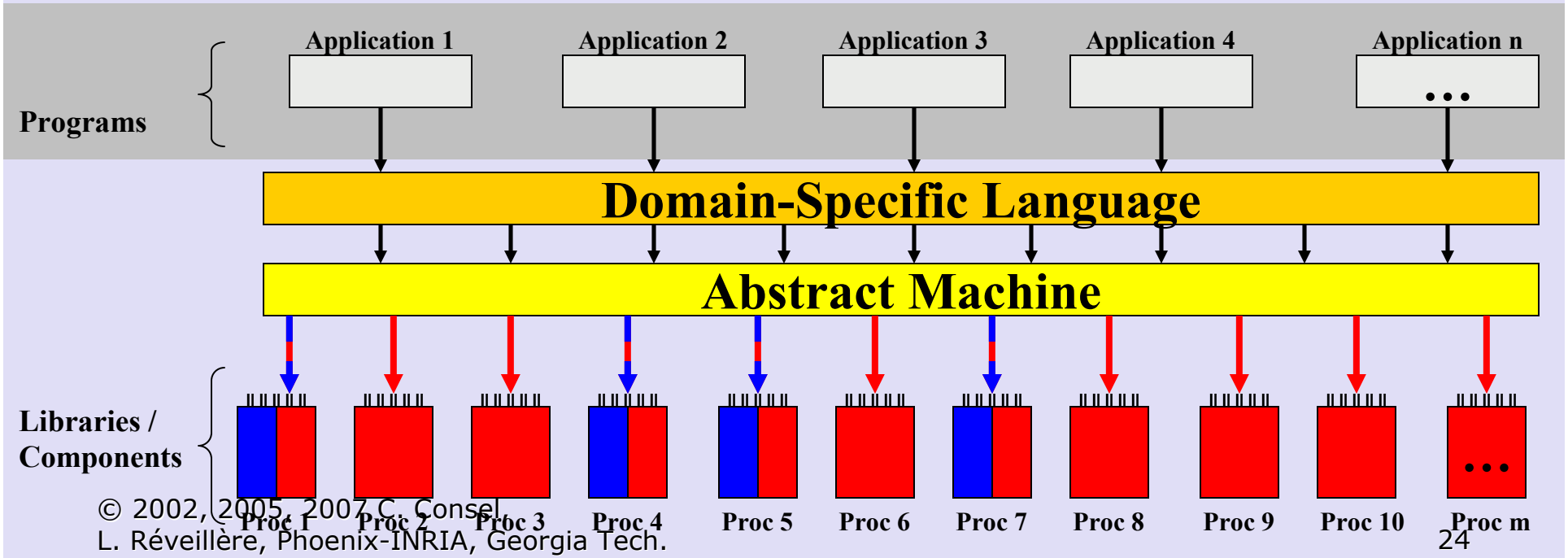
- General-purpose language
  - For each call
    - Prologues/epilogues (still)
  - For each call sequence
    - Repetitive/*required* call patterns
    - Repetitive/*required* checks



Applications: *Need for Domain-Specific Language*

- Interface abstract machine
- Designate a family member
- Domain specific constructs (abstractions/notations)
- Restricted/enriched semantics

- Re-use
- Expertise
- Conciseness
- Verification
- Productivity
- Performance

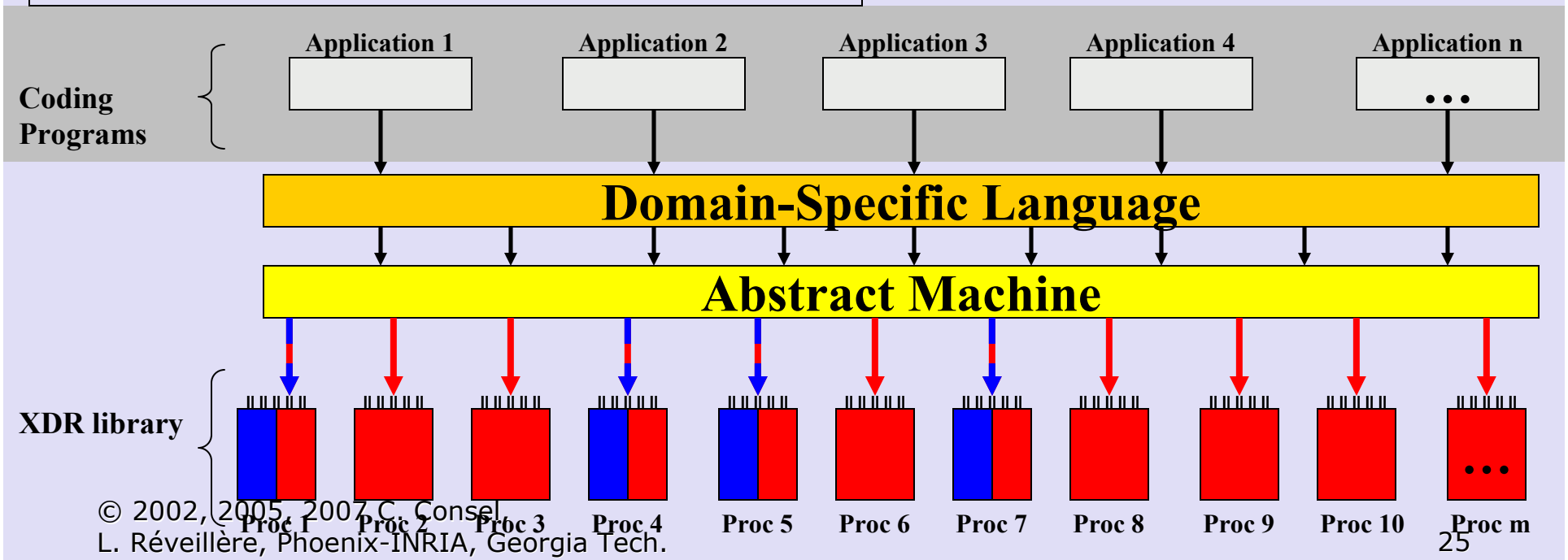


Key concept:
Data Structure Descriptions

XDR language

```
union result switch (int error){
  case 0:
     char data[MAX_SIZE];
  default:
     void;
}
```

- Re-use
- Expertise
- Conciseness
- Verification
- Productivity
- Performance



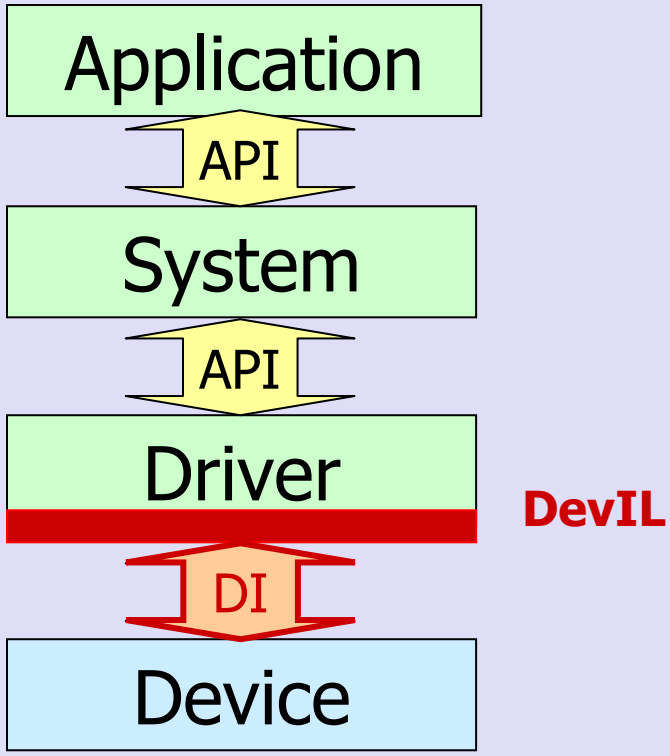
Assessing a DSL

- Existing program family
  - (Almost) objective comparisons:
    - Conciseness
    - Robustness
    - Performance
  - (Likely) subjective comparisons:

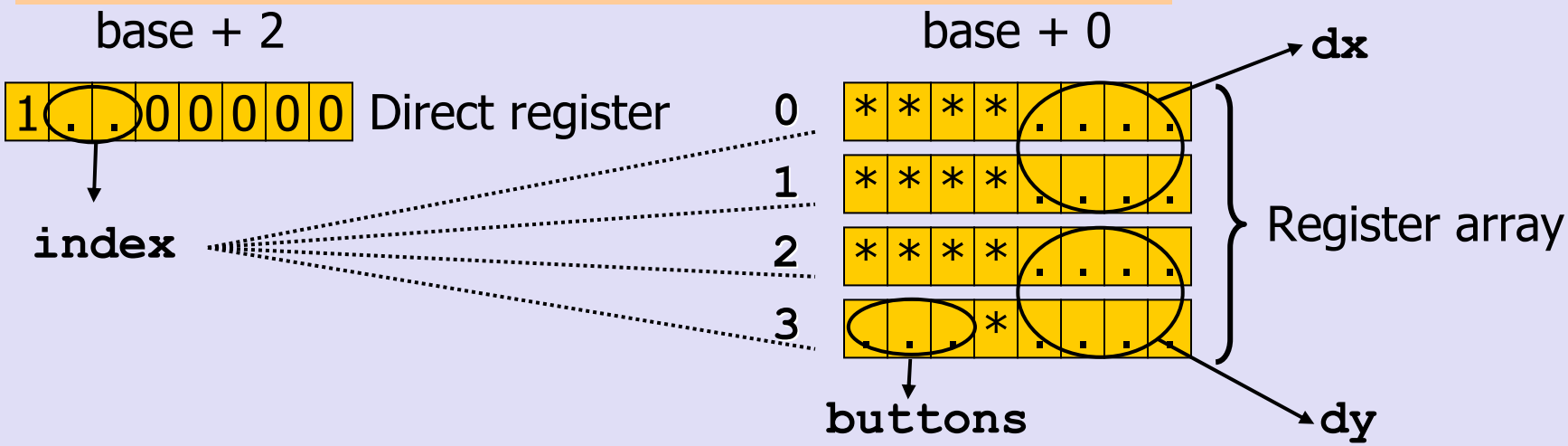
    Readability, maintainability, usability

A Program Family with our DSL: Device Driver Interface

- Commonalities: API, bit operations...
- Variations: parameters, registers…



Driver Example : Linux mouse



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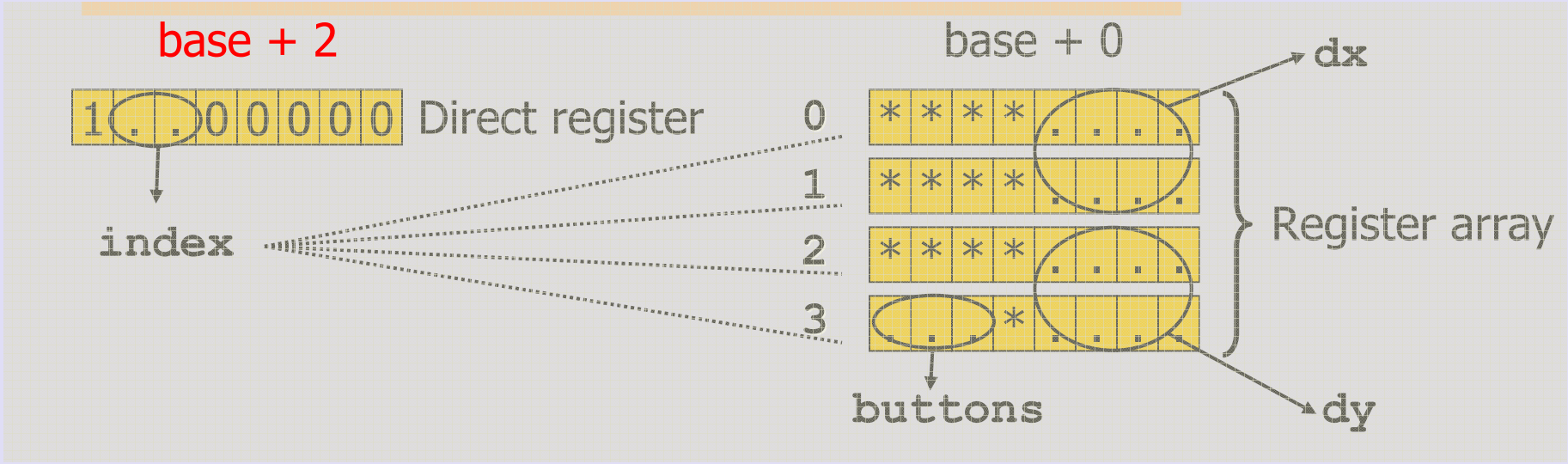
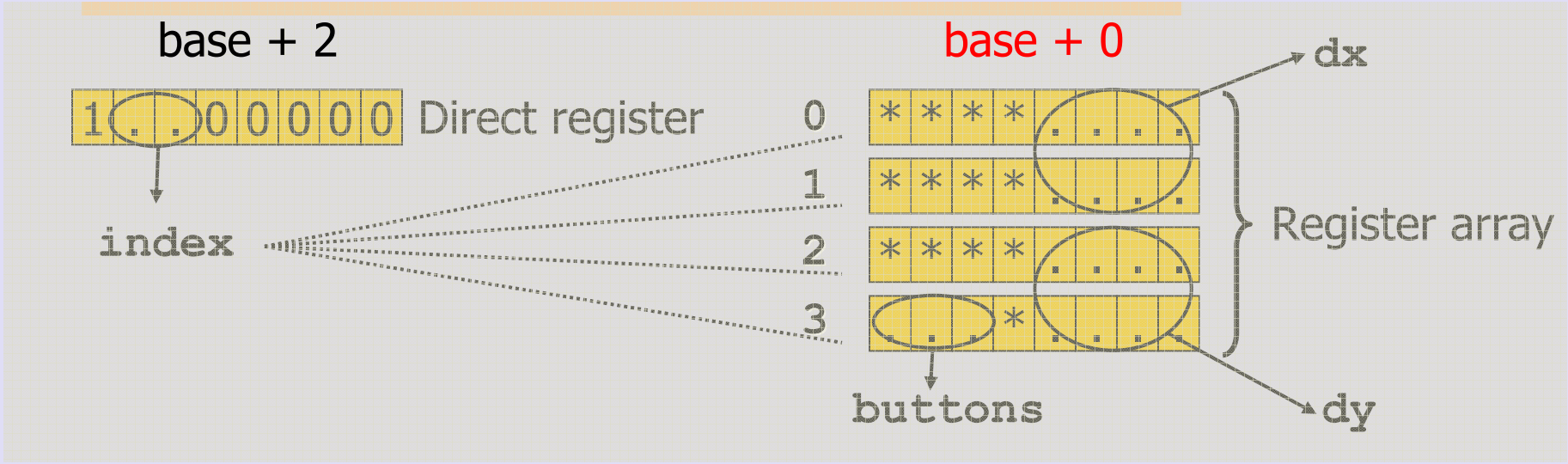


(busmouse.h)

```
#define MSE_CONTROL_PORT        0x23e
```

Driver Example : Linux mouse



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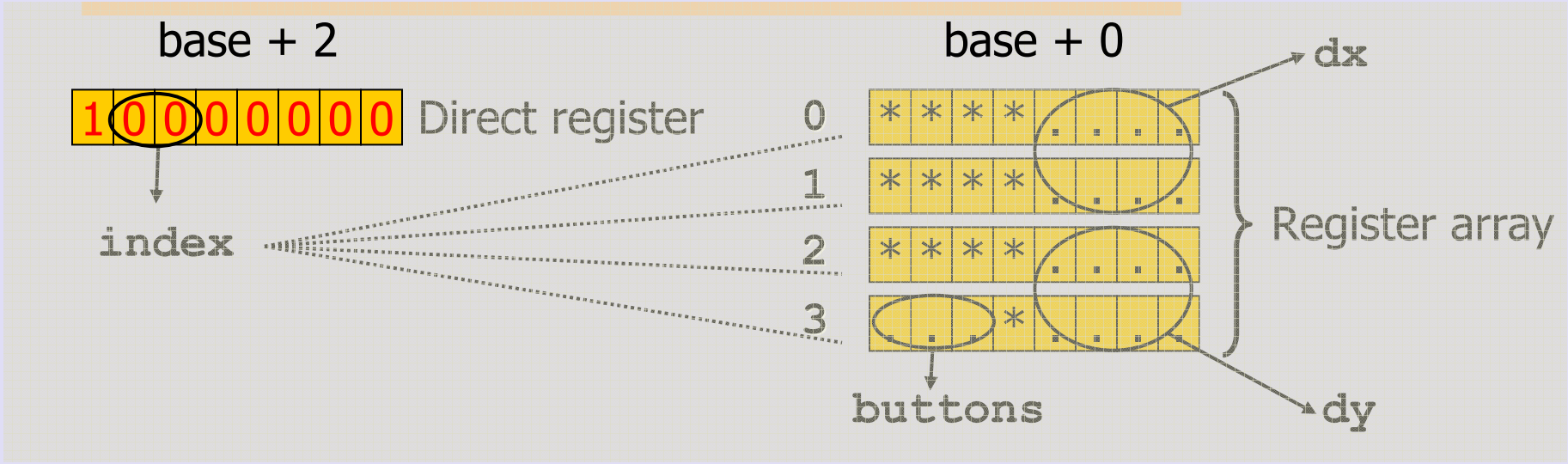
```
#define MSE_CONTROL_PORT        0x23e
#define MSE_DATA_PORT           0x23c
```

Driver Example : Linux mouse



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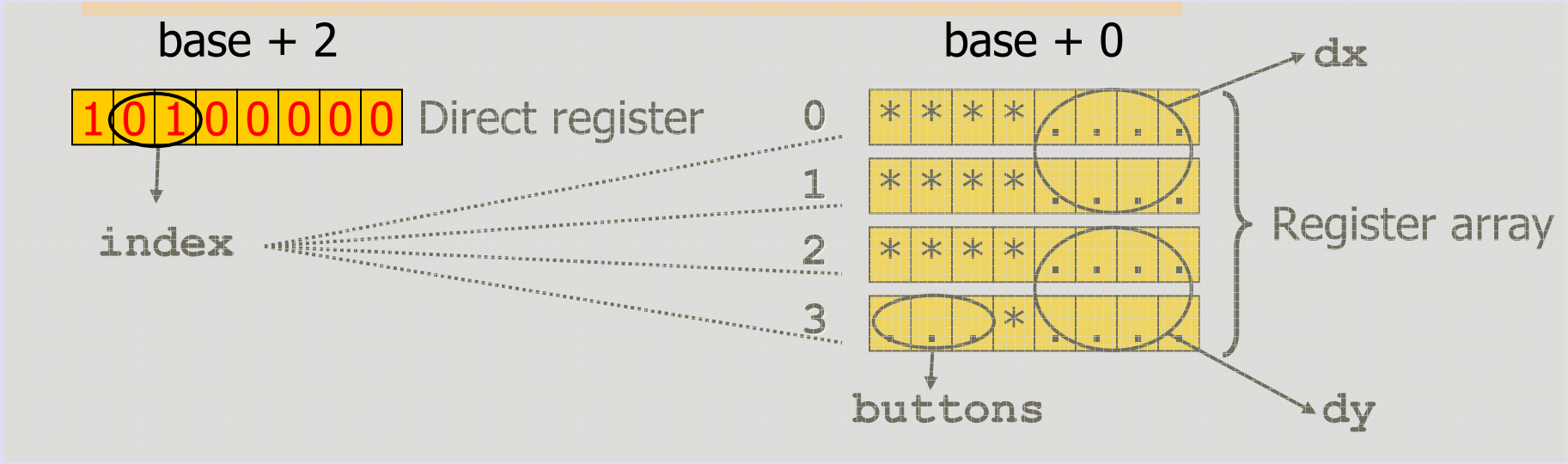
```
#define MSE_DATA_PORT          0x23e
#define MSE_CONTROL_PORT       0x23c
#define MSE_READ_X_LOW         0x80
```

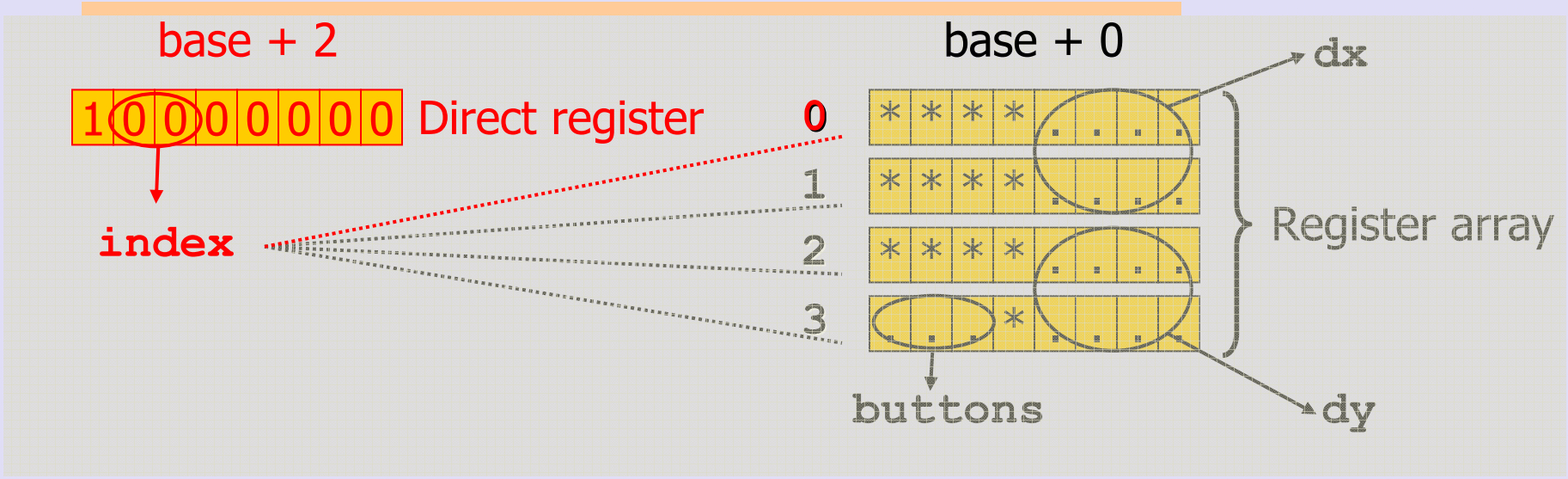
Driver Example : Linux mouse



(busmouse.h)

```
#define MSE_DATA_PORT          0x23e
#define MSE_CONTROL_PORT       0x23c
#define MSE_READ_X_LOW         0x80
#define MSE_READ_X_HIGH        0xa0
```

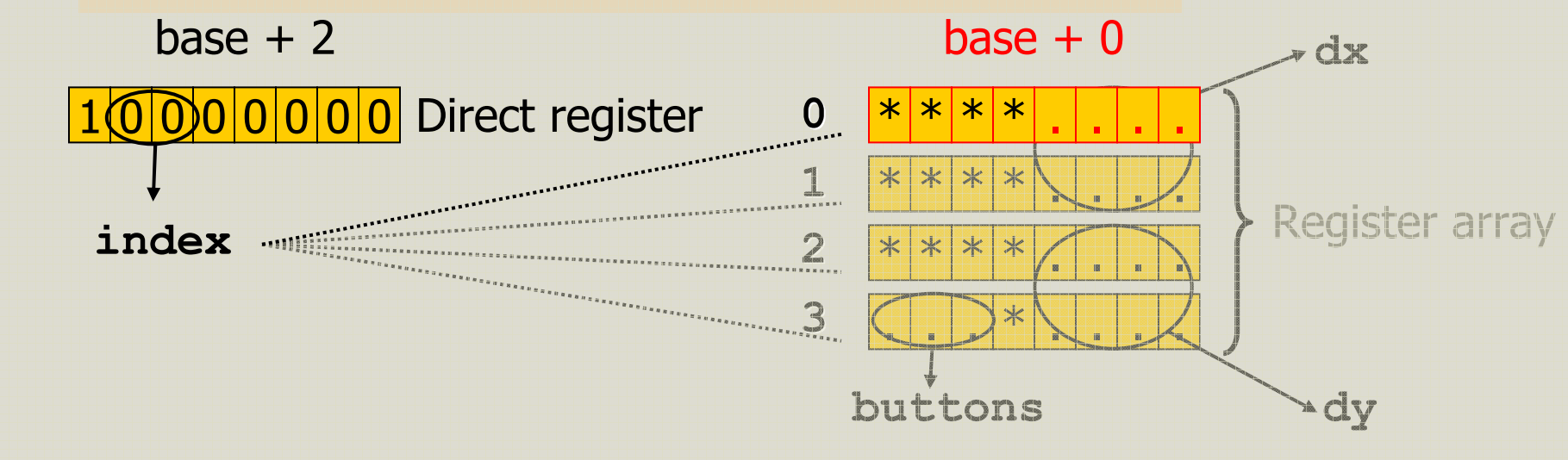
Driver Example : Linux mouse



(busmouse.c)

```
outb(MSE_READ_X_LOW, MSE_CONTROL_PORT);
```

Driver Example : Linux mouse



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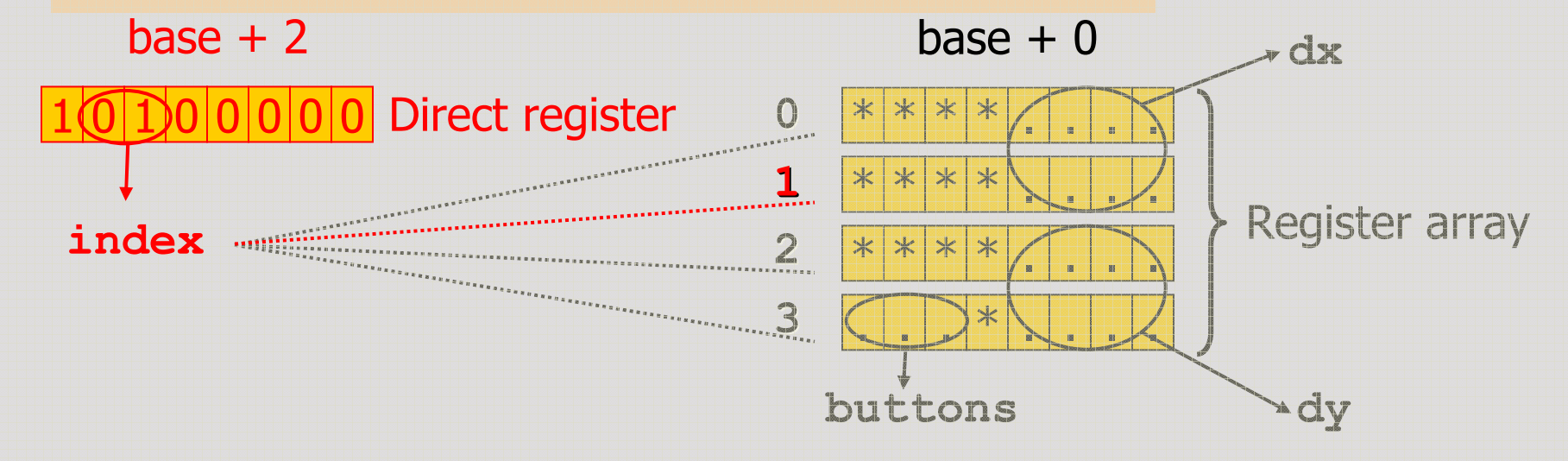
```
outb(MSE_READ_X_LOW, MSE_CONTROL_PORT);
dx = (inb(MSE_DATA_PORT) & 0xf);
```

Driver Example : Linux mouse



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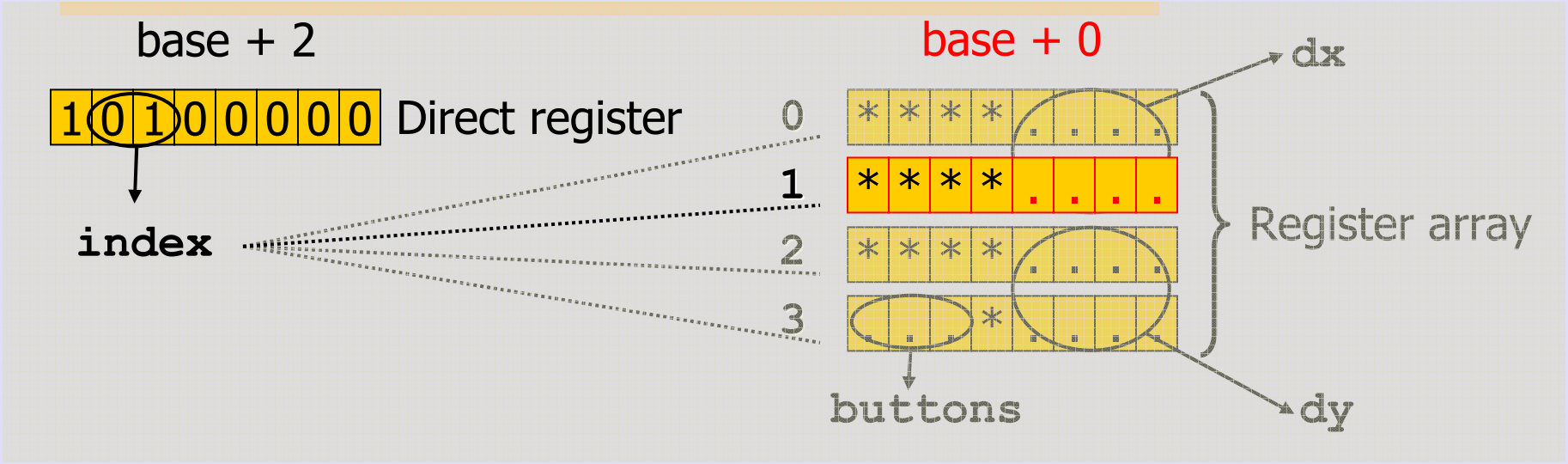

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outb(MSE_READ_X_LOW, MSE_CONTROL_PORT);
dx = (inb(MSE_DATA_PORT) & 0xf);
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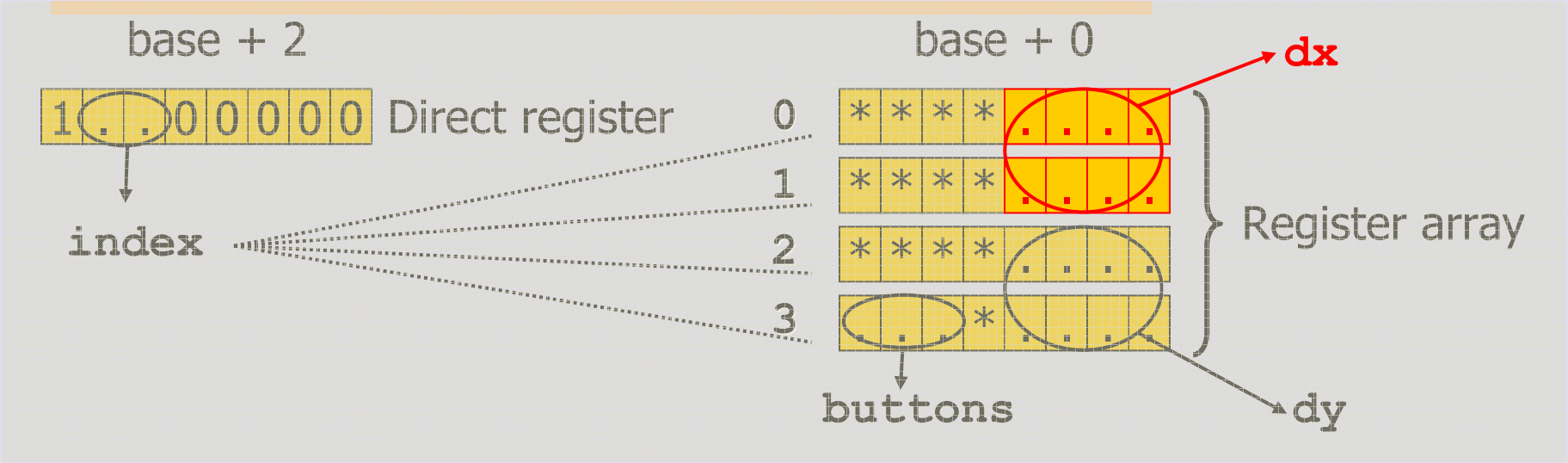
dx |= (inb(MSE_DATA_PORT) & 0xf) << 4;
```

Driver Example : Linux mouse



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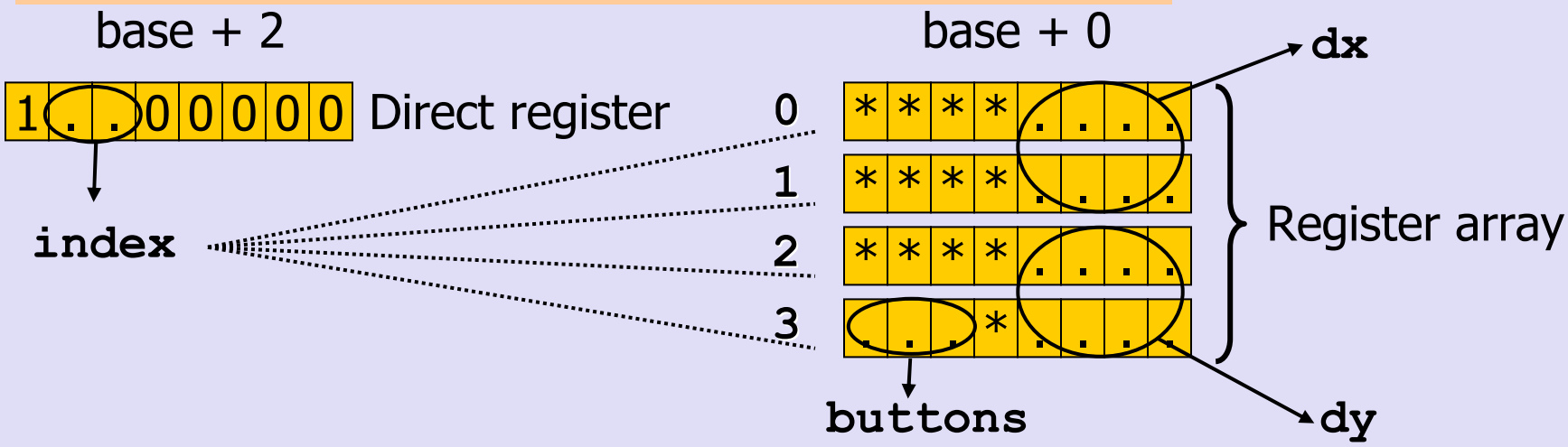

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dx = (inb(MSE_DATA_PORT) & 0xf);
outb(MSE_READ_X_HIGH, MSE_CONTROL_PORT);
dx |= (inb(MSE_DATA_PORT) & 0xf) << 4;
...
```
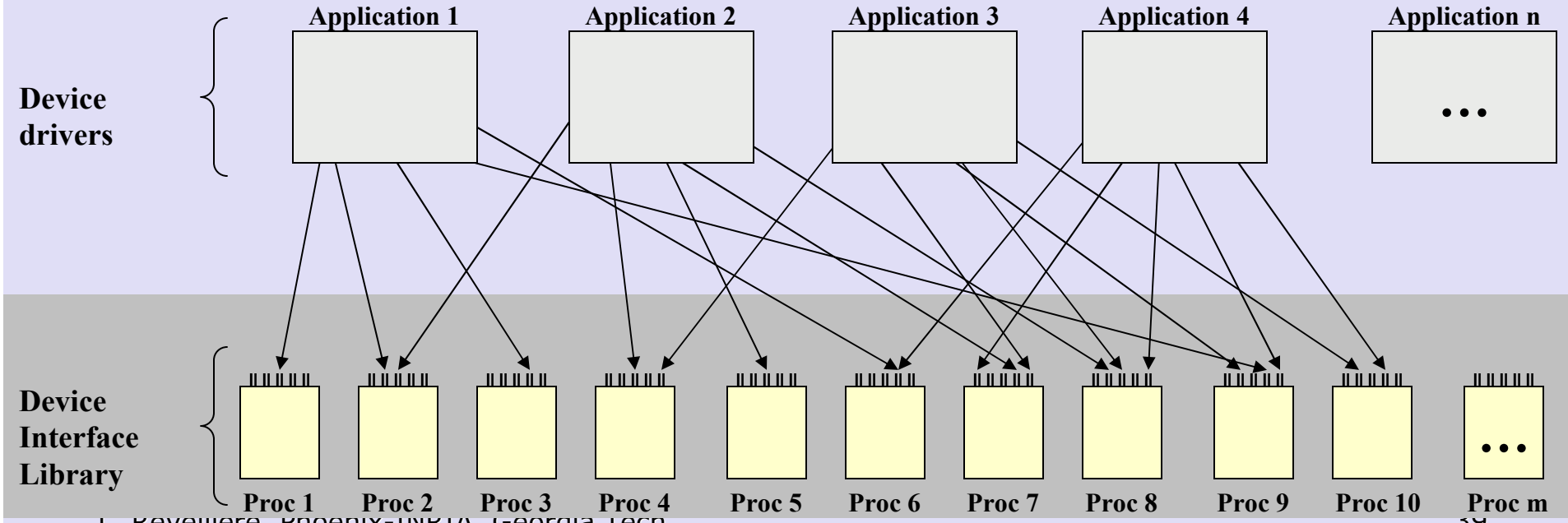

Family of Layers: Device Interface Library

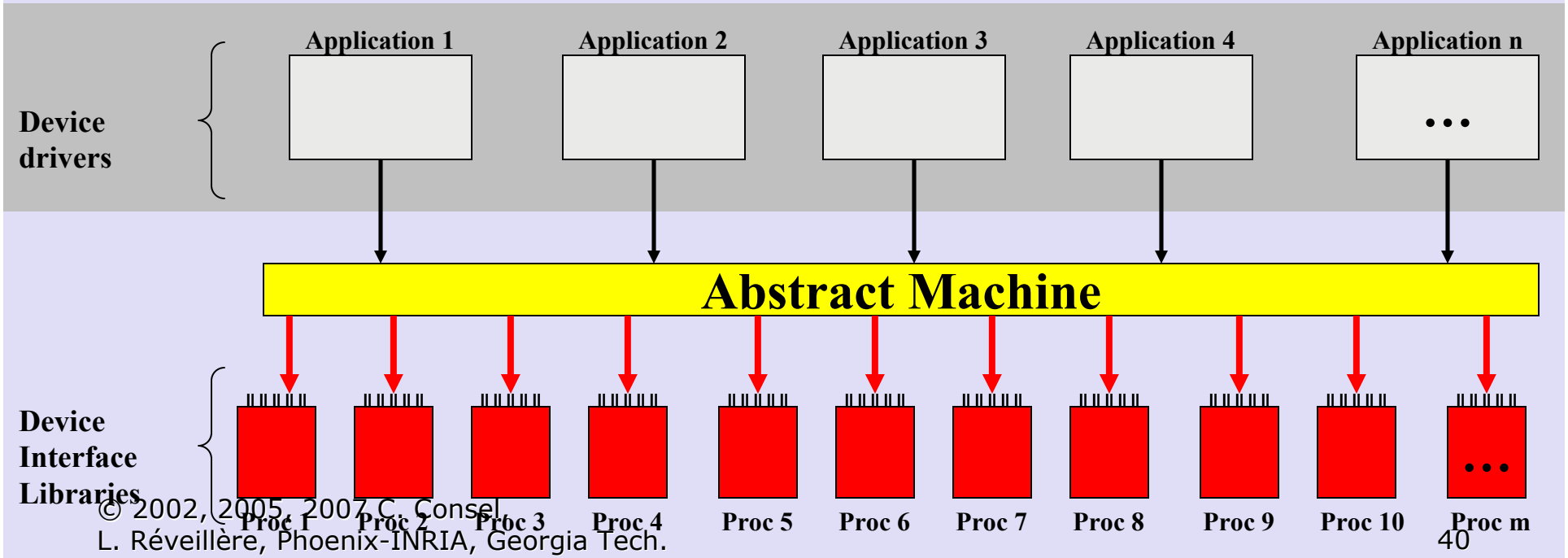
- Bit operations
- Input/output operations

- Low level
- Fine grained
- Directly mapped into machine instructions
- Implicit state



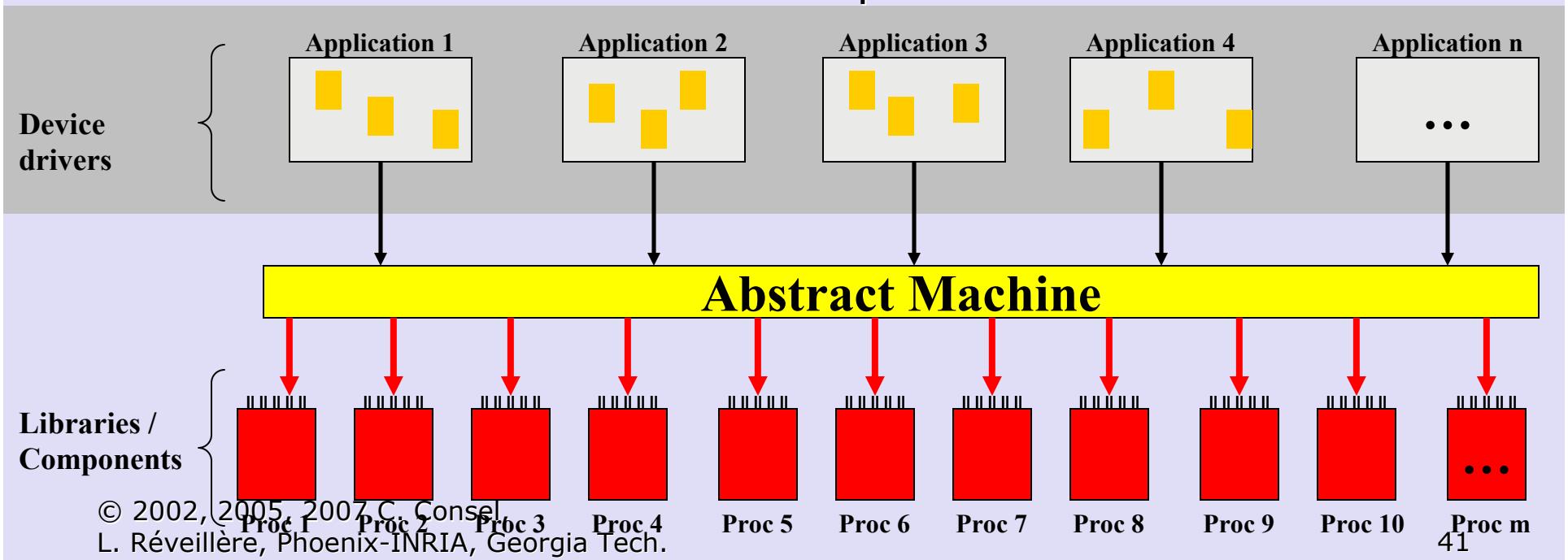
Applications:
Device Interface Abstract Machine

- Bit extraction operations
- Bit concatenation operation
- Input/output abstract operations
- Input/output checks
- Dedicated set of bit instructions
- Higher level
- More concise
- More robust



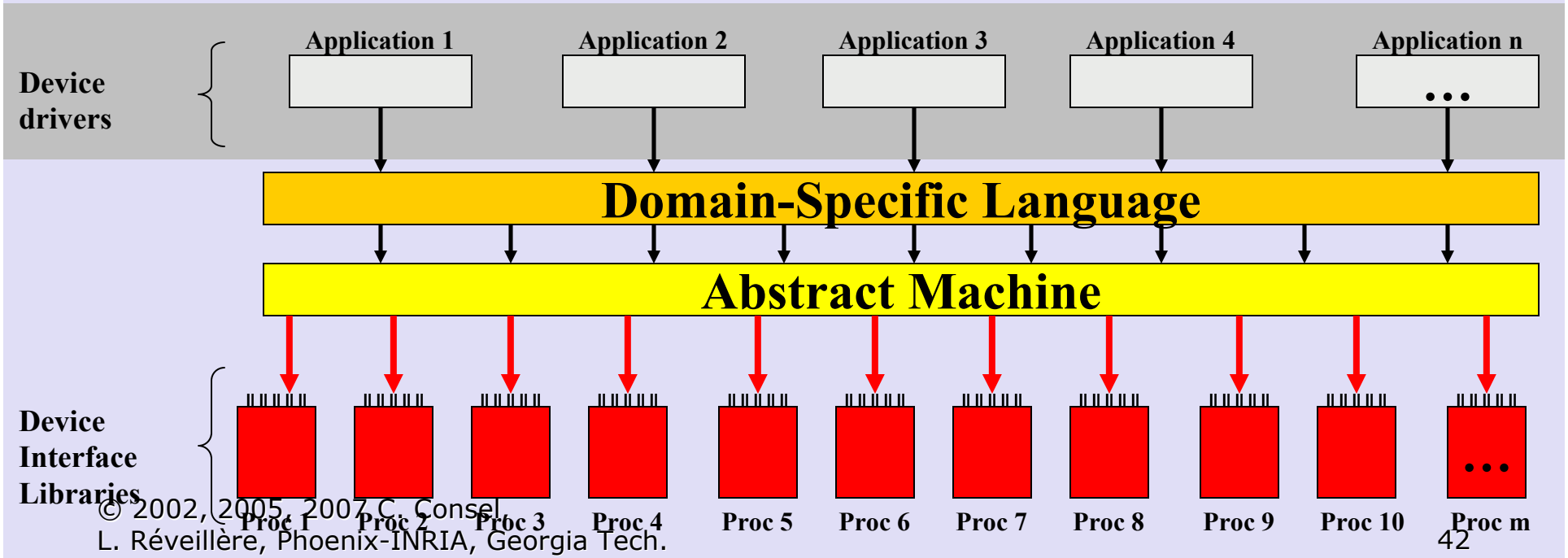
Program Family: Applications

- General-purpose language
  - General purpose glue for device communications
  - Checks subject to programmer's rigor
  - Repetitive communication sequences

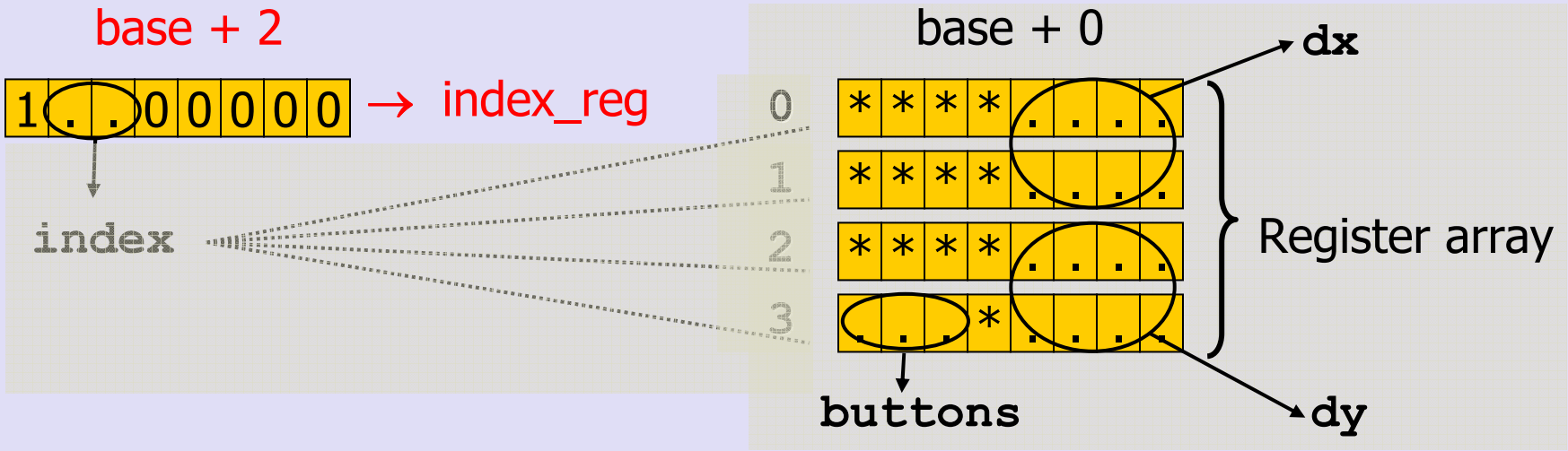


Key concept:
Layered Device Interface

- Port
  - Communication point
  - Different media: I/O, memory mapped
- Register
  - Repository of data in the device
  - indexed / paged, read / write, size, mask, …
- Variable
  - Collection of register fragments
  - Semantic value

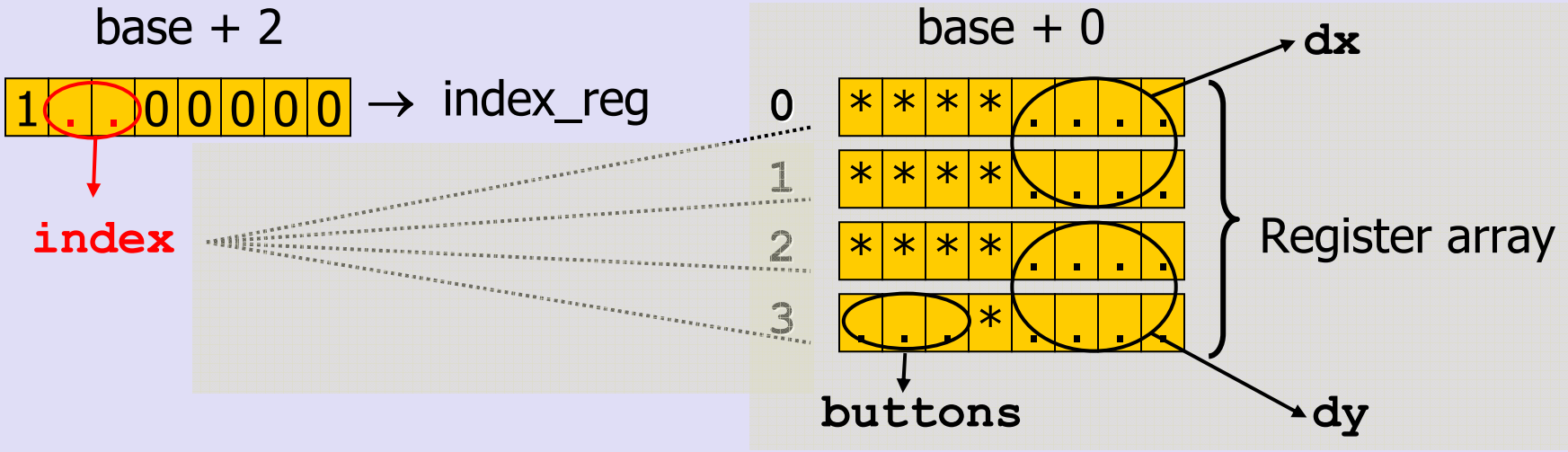


Direct Access to Register



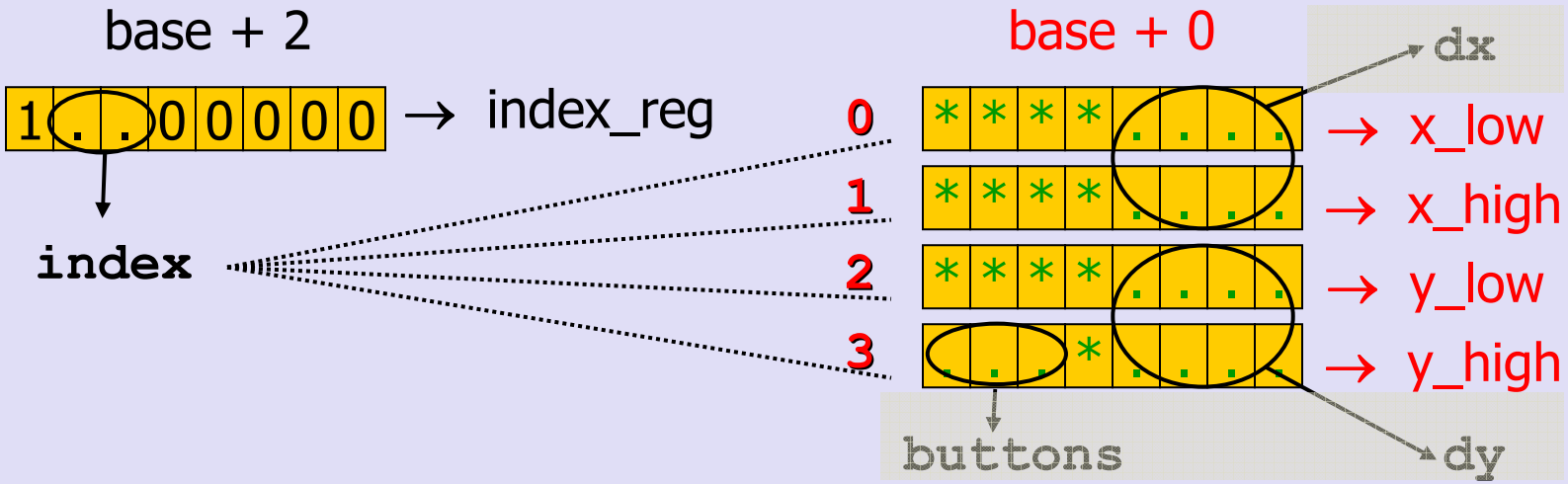

```
...
register index_reg = write base@2, mask '1..00000': bit[8];
```

Private Variable



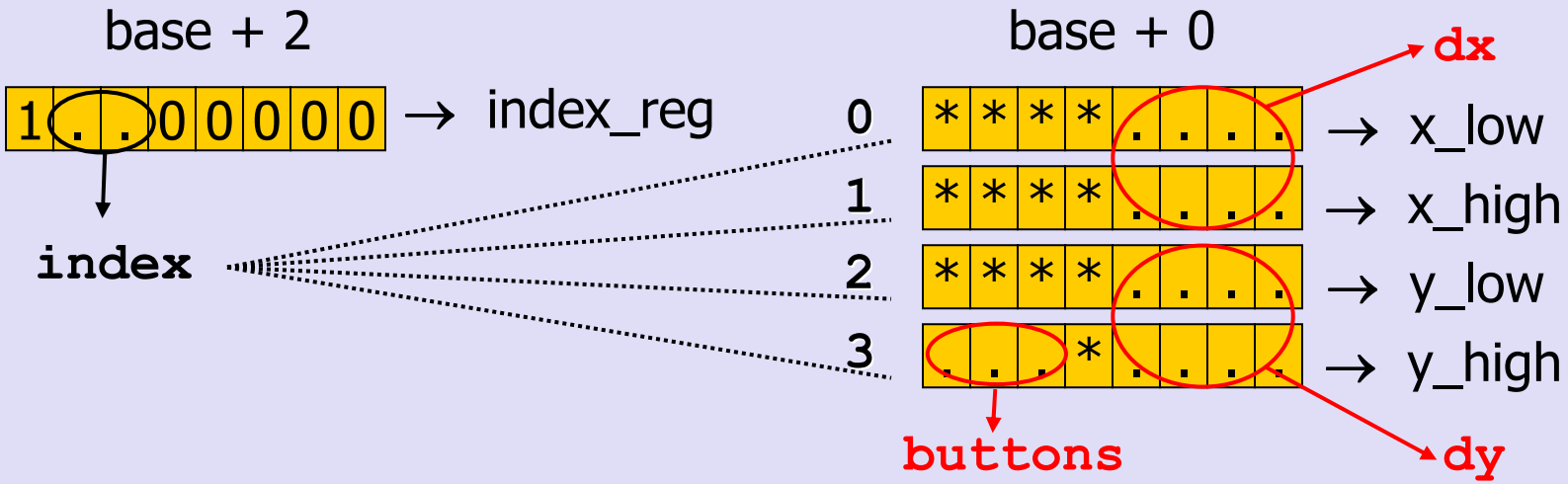

```
...
register index_reg = write base@2, mask '1..00000' : bit[8];
private variable index = index_reg[6..5] : int(2);
```

Indexed Registers




```
...
register index_reg = write base@2, mask '1..00000' : bit[8];
private variable index = index_reg[6..5] : int(2);
...
register x_low  = read base@0, pre {index = 0}, mask '****....' : bit[8];
register x_high = read base@0, pre {index = 1}, mask '****....' : bit[8];
...
```

Variables




```
...
register index_reg = write base@2, mask '1..00000' : bit[8];
private variable index = index_reg[6..5] : int(2);
...
register x_low  = read base@0, pre {index = 0}, mask '****....' : bit[8];
register x_high = read base@0, pre {index = 1}, mask '****....' : bit[8];
...
variable dx = x_high[3..0] # x_low[3..0], volatile : signed int(8);
variable dy = y_high[3..0] # y_low[3..0], volatile : signed int(8);
```

Comparison

```
outb(MSE_READ_X_LOW, MSE_CONTROL_PORT);
dx = (inb(MSE_DATA_PORT) & 0xf);
outb(MSE_READ_X_HIGH, MSE_CONTROL_PORT);
dx |= (inb(MSE_DATA_PORT) & 0xf) << 4;
outb(MSE_READ_Y_LOW, MSE_CONTROL_PORT );
dy = (inb(MSE_DATA_PORT) & 0xf);
outb(MSE_READ_Y_HIGH, MSE_CONTROL_PORT);
buttons = inb(MSE_DATA_PORT);
dy |= (buttons & 0xf) << 4;
```

Existing code

Devil

```
variable dx = x_high[3..0] # x_low[3..0],volatile
    : signed int(8);
variable dy = y_high[3..0] # y_low[3..0],volatile
    : signed int(8);
```

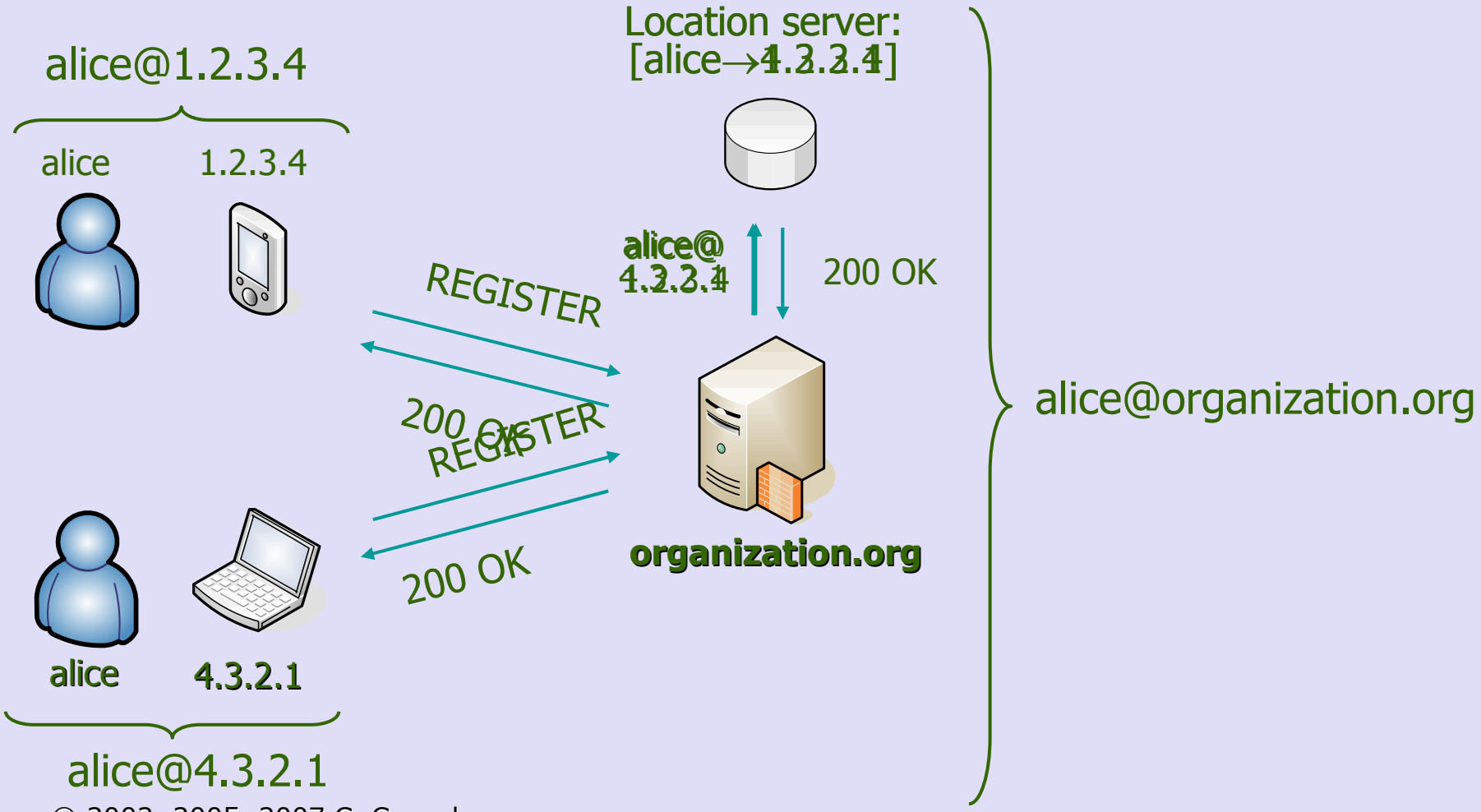
Talk Outline

- Introduction to Domain Specific Languages (DSL)
- **Overview of SIP**
- SPL: A DSL for communication services
- Properties of SPL
- Summary

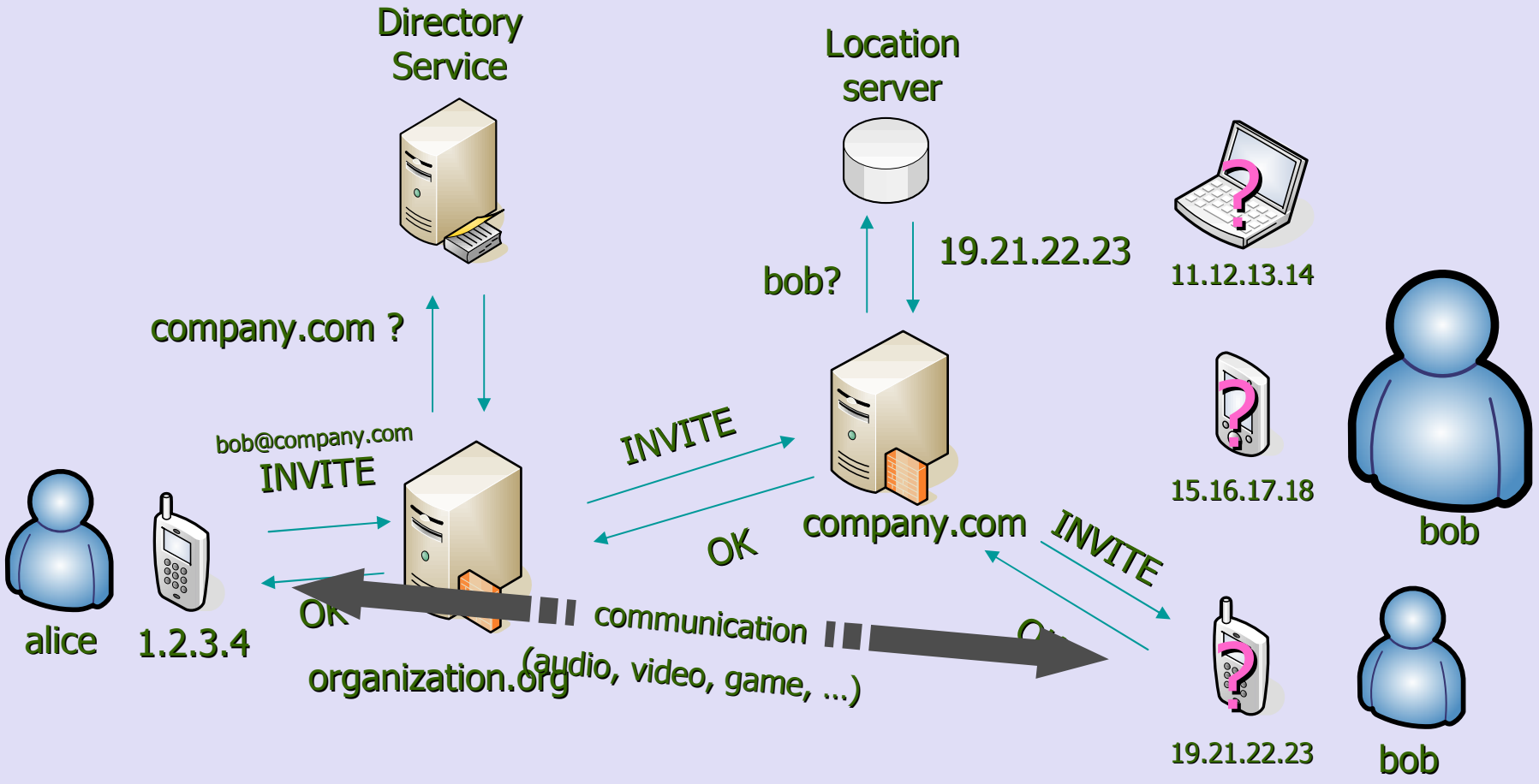
What is SIP?

- SIP: Session Initiation Protocol
  - Voice over IP and 3G mobile phones
  - Standardized by IETF, adopted by ITU
- Protocol for creating, modifying and terminating sessions between devices
- Based on a client/server model
- Mobility: SIP URI

SIP: Mobility

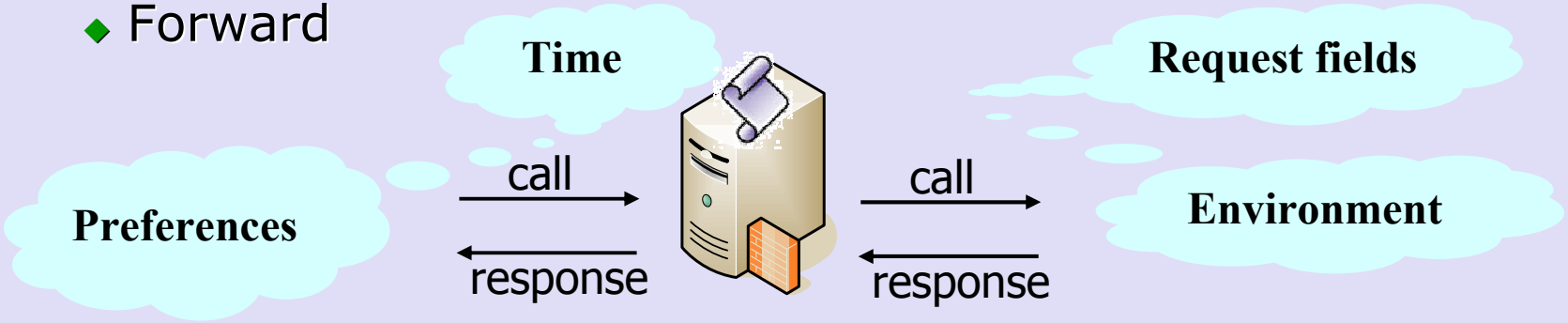


SIP: Typical Call Flow



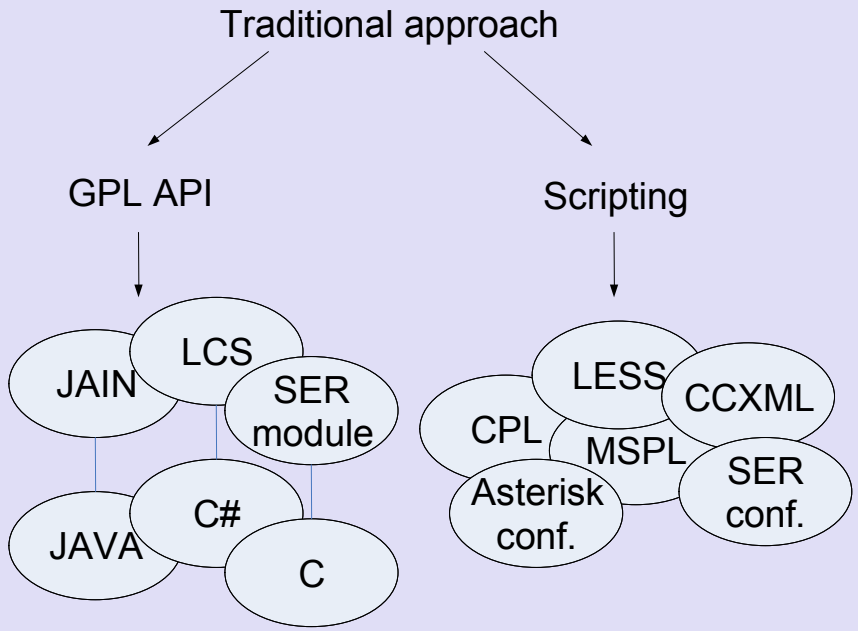
Programming Telephony Services

- A service processes SIP messages (incoming/outgoing) on behalf of a person or a group of persons
  - Service logic
  - Signalling actions
    - Reject
    - Forward



Existing Solutions

- Use General Purpose Languages:
  - Microsoft SIP APIs – C#
  - SIP Express Router – C-like and C
  - JAIN SIP – Java
- Requires extensive knowledge of existing protocols

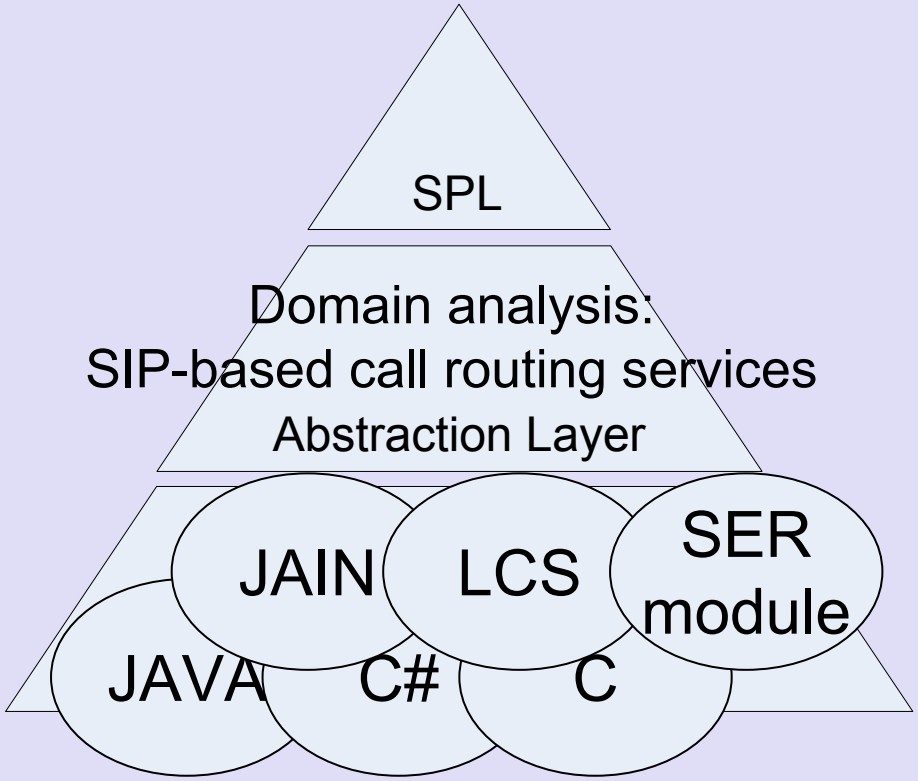


Expressive, but unsafe

Why a DSL for Telephony Services?

- Telephony services are a rich domain
- SIP is a rich protocol
- SIP has many companion protocols
- Programming services requires expertise in multiple areas
  - Protocols
  - Networking
  - Platform
- Few trained programmers
- Reliability is critical
- Performance is critical

DSL Based Approach



Example

- Abstract service specification
  - When registering
    - Set a counter to 0
  - When a call is received
    - If the callee rejects the call :
      - Forward the call to the secretary
    - Otherwise
      - Increment the counter
  - When un-registering
    - Log the value of the counter

Example: JAIN SIP Code

```
public class Counter implements SipListener {

  public void processRequest(RequestEvent requestEvent) {
    try {
      Request rq_request = requestEvent.getRequest();
      SipProvider rq_sipProvider = (SipProvider) requestEvent.getSource();
      String method = rq_request.getMethod();
      if (method.equals(Request.REGISTER)) {
        if (!registrar.hasExpiresZero(rq_request)) {
          if (!registrar.hasRegistration(rq_request)) {
              State state = new State();
              int ident   = env.getId(rq_request);
              env.setEnv(ident, state);
              state.count = 0;
              rq_sipProvider.sendRequest(rq_request);
              return;
          } else {
              rq_sipProvider.sendRequest(rq_request);
              return;
          }
        } else if (lib.registrar.hasRegistration(rq_request)) {
              int ident = env.getId(rq_request);
              State state = (State)env.getEnv(ident);
              log(state.count);
              env.delEnv(ident);
              rq_sipProvider.sendRequest(rq_request);
              return;
        } else {
           rq_sipProvider.sendRequest(rq_request);
           return;
        }
      } else if (method.equals(Request.INVITE)) {
         ClientTransaction ct = rq_sipProvider.getNewClientTransaction(rq_request);
         ct.sendRequest();
         return;
      } else {
        rq_sipProvider.sendRequest(rq_request);
              return;
      }
    } catch(Exception ex){ […] }
  }

  […]
```

```
[…]

public void processResponse(ResponseEvent responseEvent) {
  try {
    Response rs_response = responseEvent.getResponse();
    SipProvider rs_sipProvider = (SipProvider) responseEvent.getSource();
    rs_responseCode = rs_response.getStatusCode();
    ClientTransaction ct = responseEvent.getClientTransaction();
    if ( clientTransaction != null ) {
      Request rs_request = ct.getRequest();
      String method = rs_request.getMethod();
      int ident = env.getId(rs_request);
      State state = (State)env.getEnv(ident);
      if (method.equals(Request.INVITE)) {
        if (rs_responseCode >= 300) {
          AddressFactory addressFactory = lib.getAddressFactory();
          SipURI sipURI =
                addressFactory.createSipURI("secretary","company.com");
          rs_request.setRequestURI(sipURI);
          int ident = env.getId(rs_request);
          env.delEnv(ident);
          sipProvider.sendRequest(rs_request);
           return;
        } else {
          state.count++;
          ServerTransaction st = rs_request.getNewServerTransaction();
          st.sendResponse(rs_response);
           return;
        }
      } else {
        rs_sipProvider.sendResponse(rs_response);
         return;
      }
    } else {
      rs_sipProvider.sendResponse(rs_response);
       return;
    }
  } catch (Exception ex) { […] }
}

[…]
```

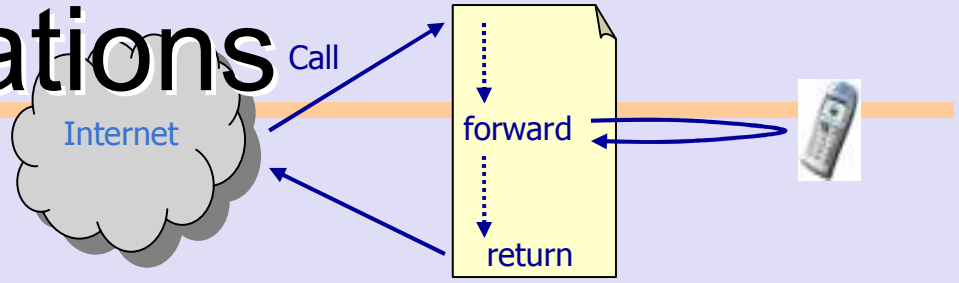
Example: SPL Code

```
service Counter {
  processing {
    local void log (int);

    registration {
      int count;

      response outgoing REGISTER() {
        count = 0;
        return forward;
      }

      void unregister() {
        log (count);
      }

      dialog {
        response incoming INVITE() {
          response resp = forward;
          if (resp != /SUCCESS) {
              return forward 'sip:secretary@company.com';
          } else {
            count++;
            return resp;
          }
}}}}}
```

SPL Components

- Event handlers and signaling operations
- Session
- Hierarchical sessions
  - Service
  - Registration
  - Dialog
- Inter-event control flow

Event Handlers and Signaling Operations



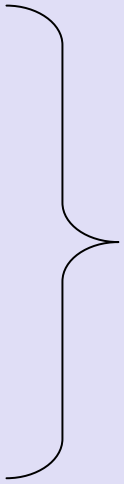
SPL Service

```
response incoming INVITE() {
    […]
    response resp = forward;
    if (resp == /ERROR) {
     resp = forward 'sip:phoenix.secretary@inria.fr';
    }
    return resp;
}
```

```
// Deny Service
response incoming INVITE() {
    return /ERROR/CLIENT/BUSY_HERE;
}
```

Session

- **INVITE**
- **BYE**
- **REINVITE**
- …



Dialog = ID

uri caller;
time start;
…

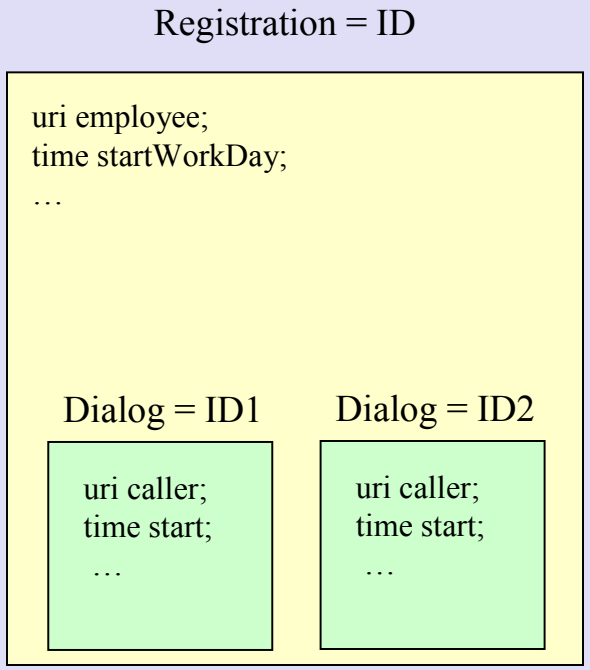
Session: The Dialog Session Example

```
dialog {
  uri caller;
  time start;

  response incoming INVITE() {
    caller = FROM;
    return forward;
  }

  void incoming ACK(){
    if(caller == 'sip:my.wife@home.fr')
      log("Personal call");
    start = getTime();
  }

  response BYE() {
    string duration = time_to_string(getTime() - start);
    log("Call: "+ duration +" "+uri_to_string(caller));
    return forward;
  }
}
```

Hierarchical Sessions

- **REGISTER**
- **REREGISTER**
- ***unregister***

- **INVITE**
- **BYE**
- **REINVITE**
- …

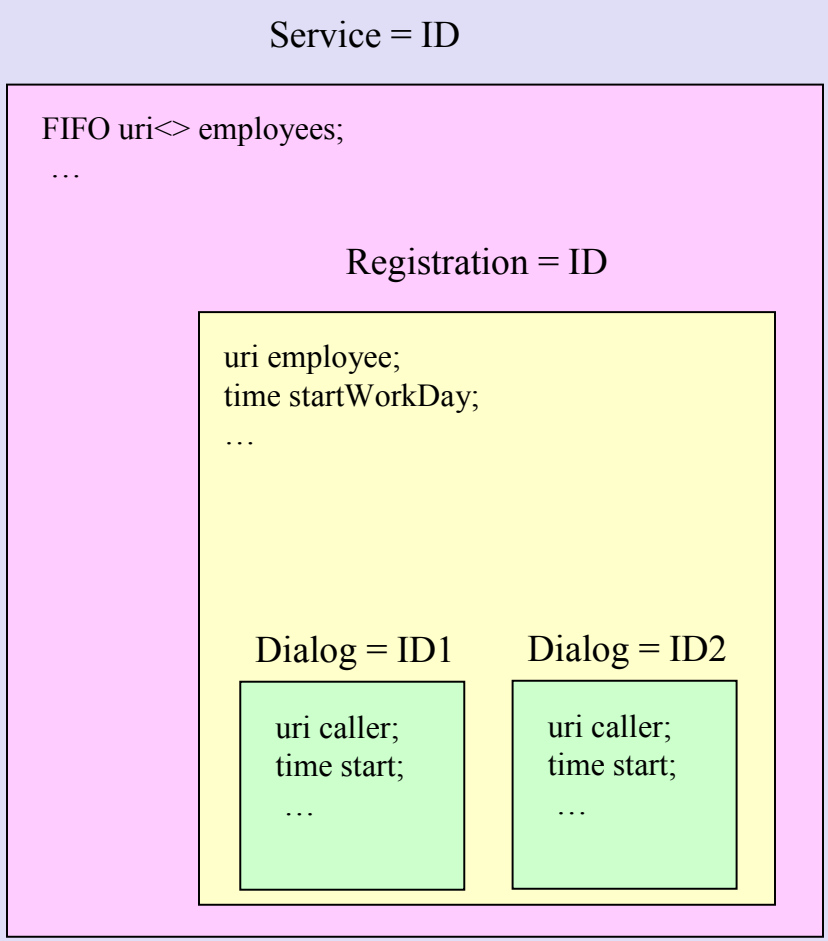


Hierarchical Sessions: Example

```
registration {
  uri employee;
  time startWorkDay;

  response outgoing REGISTER() {
    startWorkDay = getTime();
    employee = FROM;
    return forward;
  }

  void unregister() {
    string duration = time_to_string(getTime() - startWorkDay);
    log("WorkDay: "+ duration +" "+uri_to_string(employee));
    return;
  }

  dialog {
    uri caller; time start;

    ...
  }
}
```

Hierarchical Sessions

- ***deploy***
- ***undeploy***
  - **REGISTER**
  - **REREGISTER**
  - ***unregister***
    - **INVITE**
    - **BYE**
    - **REINVITE**
    - …

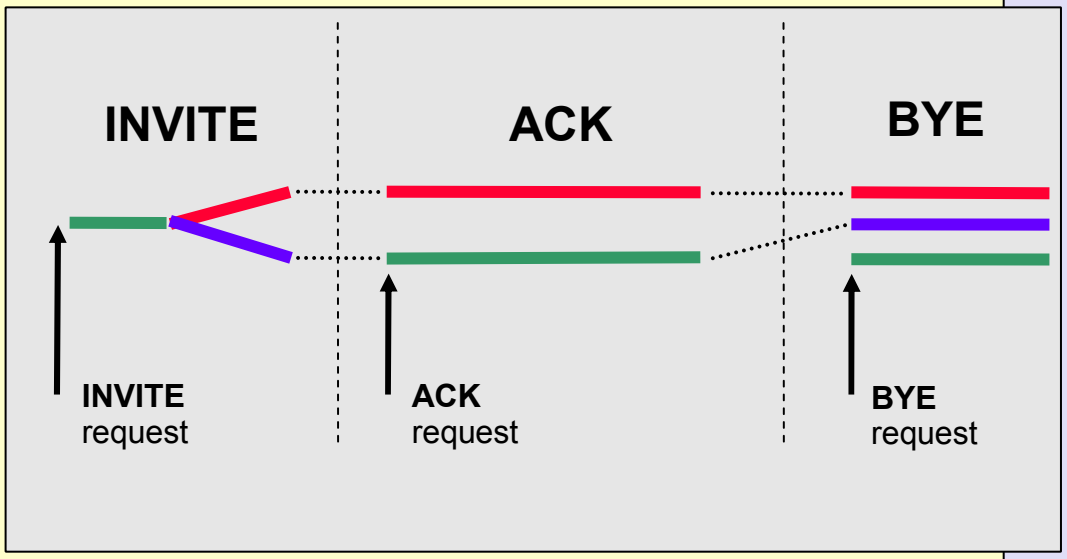


Hierarchical Sessions: Example (cont'd)

```
service hotline {
  ...
  processing {
    uri<100> employees = <>;

    void deploy() {...}
    void undeploy() {...}

    registration {...

      response outgoing REGISTER() {
        startWorkDay = getTime();
        employee = FROM;
        push employees employee;
        return forward;
      }
      ...

      dialog { ...
        response incoming INVITE() {
          return forward employees;
        }
      }
    }
  }
}
```

Inter-Event Control Flow

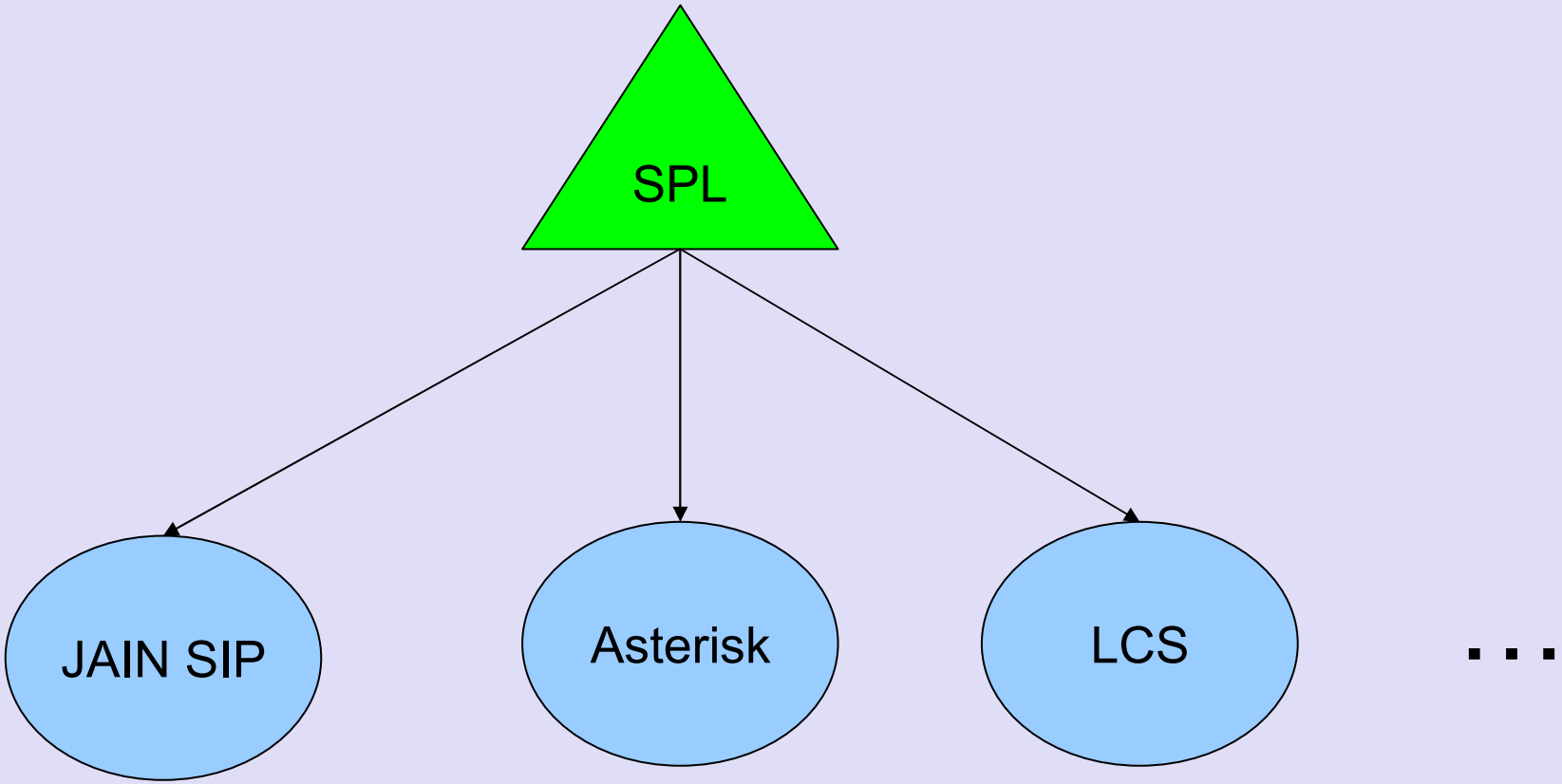
```
dialog {
  response incoming INVITE() {
    response r;
    ...
    if (...) {
      ...
      return r branch hotline;
    }
    else {
      ...
      return r branch personal;
    }
  }

  void incoming ACK(){
    branch hotline {... }
    branch default {... }
  }

  response BYE() {

    branch hotline  {... }

    branch personal {... }

    branch default  {... }
  }
}
```



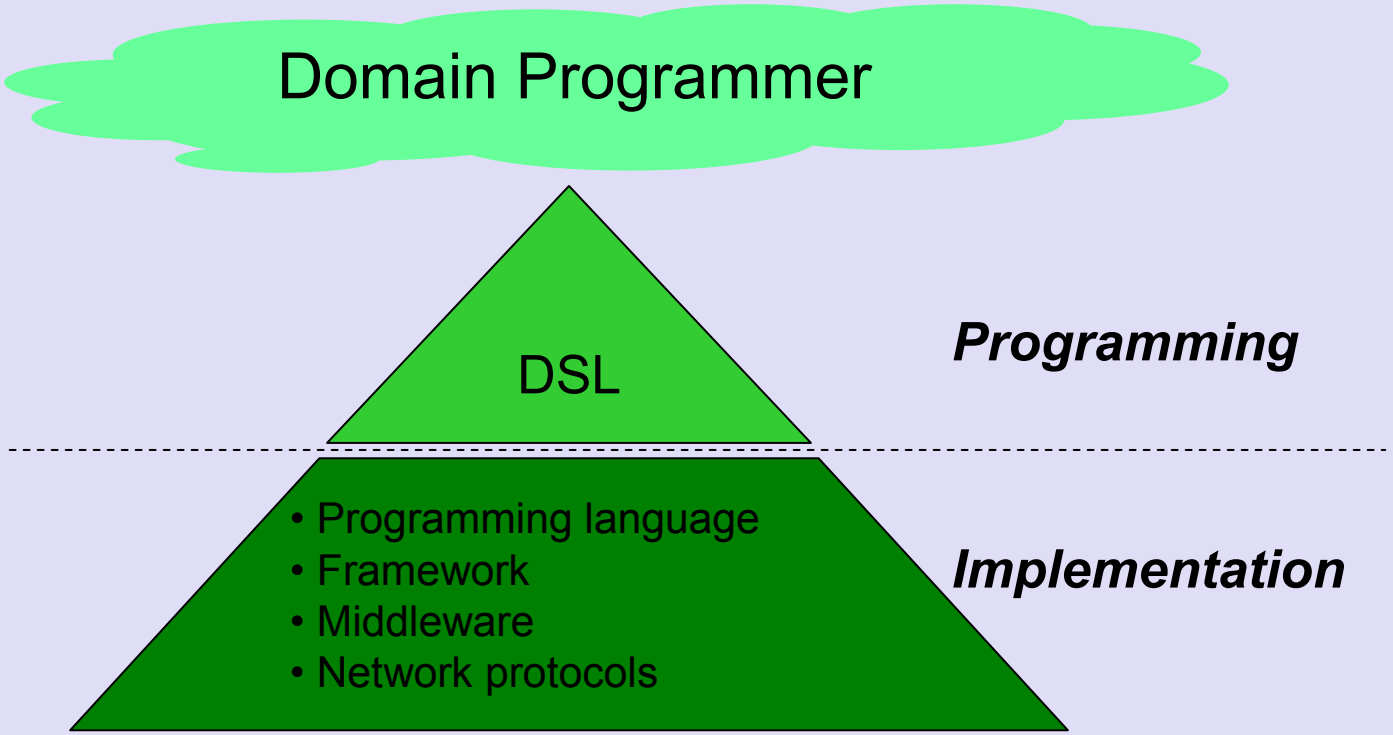
Talk Outline

- Introduction to Domain Specific Languages (DSL)
- Overview of SIP
- SPL: A DSL for communication services
- **Properties of SPL**
- Summary

Portability of SPL Services



Abstraction Layers



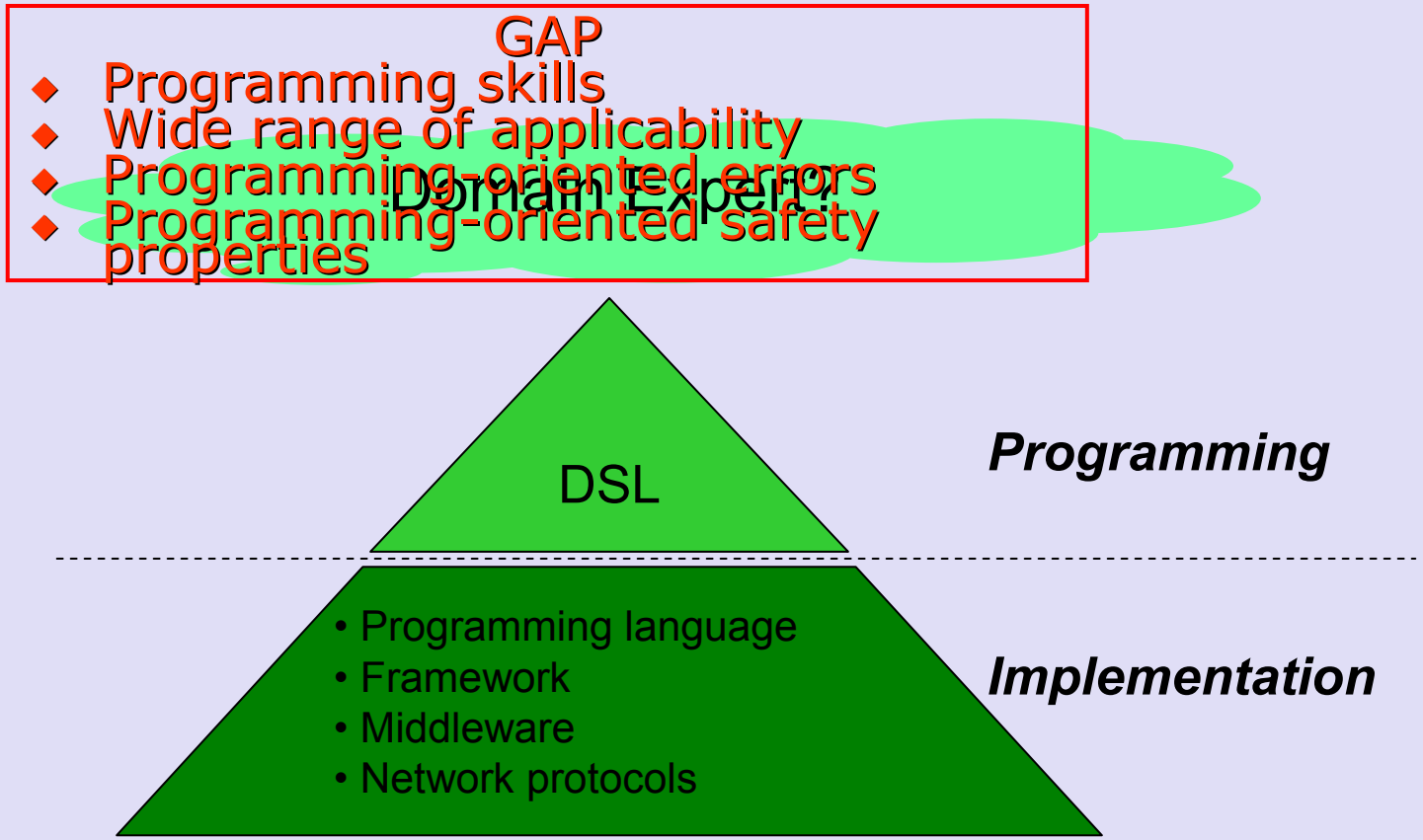
SPL

```
service example {
 [...]
 response incoming INVITE() {
  response r =
   forward 'sip:bob@phone.example.com';
  if (r == /ERROR/CLIENT/BUSY_HERE)
   return
    forward 'sip:bob@voicemail.example.com';
  else
   if (r == /ERROR) {
    if (FROM == 'sip:boss@example.com')
     return forward 'tel:+19175554242';
    return r;
  }
 }
 [...]
}
```

≈ JAIN SIP

```
public class Example implements SipListener {
 [...]
 private AddressFactory factory = getAddressFactory();

 public void processRequest (RequestEvent requestEvent) {
  Request rq_request = requestEvent.getRequest();
  SipProvider rq_sipProvider = (SipProvider) requestEvent.getSource();
  String method = rq_request.getMethod();
  [...]
  if (method.equals (Request.INVITE)) {
   SipURI uri = factory.createSipURI ("bob", "phone.example.com");
   rq_request.setRequestURI (uri);
   ClientTransaction ct = rq_sipProvider.getNewClientTransaction(rq);
   ct.sendRequest (rq_request);
  ... }

 public void processResponse (ResponseEvent responseEvent) {
  ClientTransaction rs_ct = responseEvent.getClientTransaction();
  if (rs_ct != null) {
   Request rs_request = rs_ct.getRequest();
   Response rs_response = responseEvent.getResponse();
   SipProvider rs_sipProvider = (SipProvider) responseEvent.getSource();
   String method = rs_request.getMethod();
   rs_responseCode = rs_response.getStatusCode();
   if (method.equals (Request.INVITE)) {
    if (rs_responseCode == 486) {
     SipURI uri = factory.createSipURI ("bob", "voicemail.example.com");
     rs_request.setRequestURI (uri);
     rs_sipProvider.sendRequest (rs_request);
    } else if (rs_responseCode > 300) {
     if (rs_request.getHeader("FROM").equals("sip:boss@example.com ")) {
      TelURL tel = factory.createTelURL ("tel:+19175554242");
      rs_request.setRequestURI (tel);
      rs_sipProvider.sendRequest (rs_request);
     } else {
      rs_sipProvider.sendResponse (rs_response);
     } ...  }
```

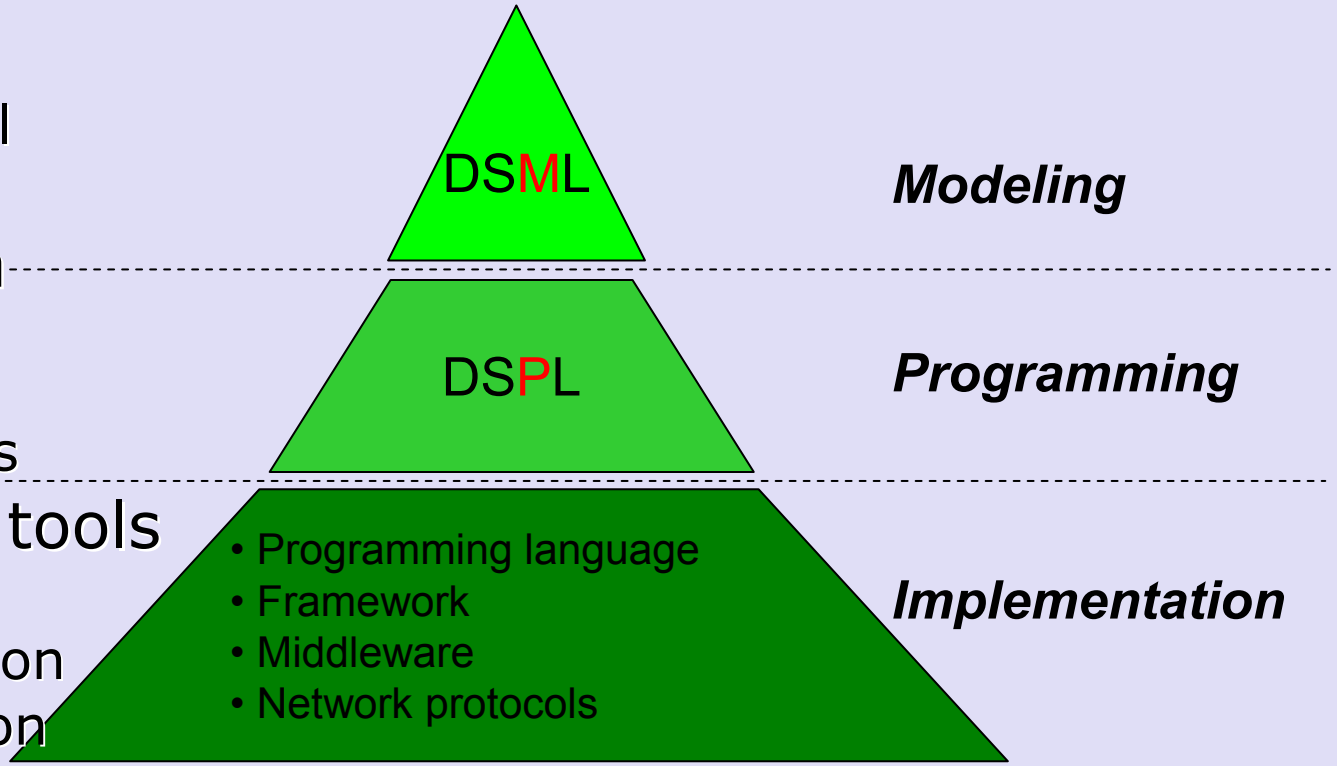
Abstraction Layers



A Layered Domain-Specific Language Approach

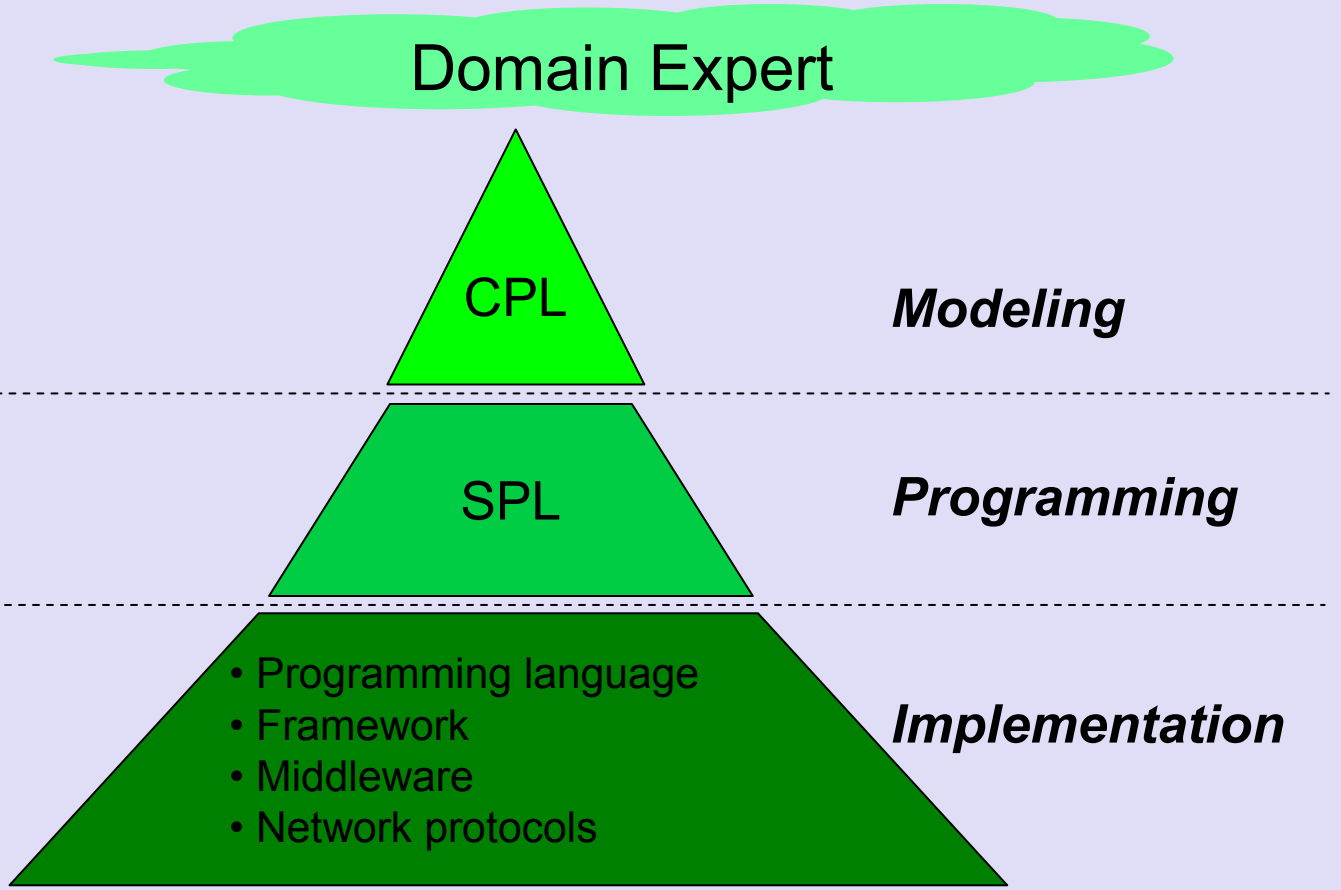
Domain Expert

- Defining a solution
  - High level
  - Simple
- Verifying a solution
  - Domain properties
- High-level tools for
  - Compilation
  - Verification

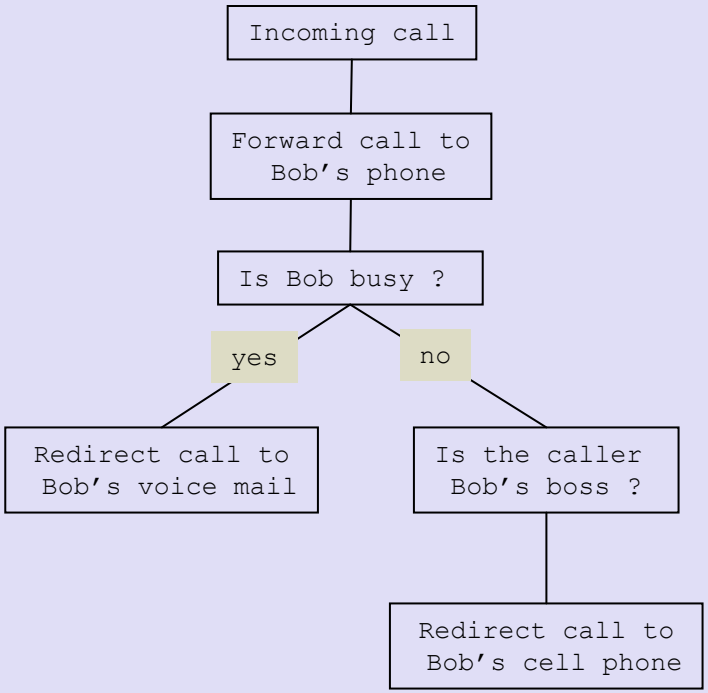


A Layered Domain-Specific Language Approach

- Defining a solution
  - Visual
  - Activity diagram
- Verifying a solution
  - Domain properties
- Compilation
  - SPL
  - Formulas

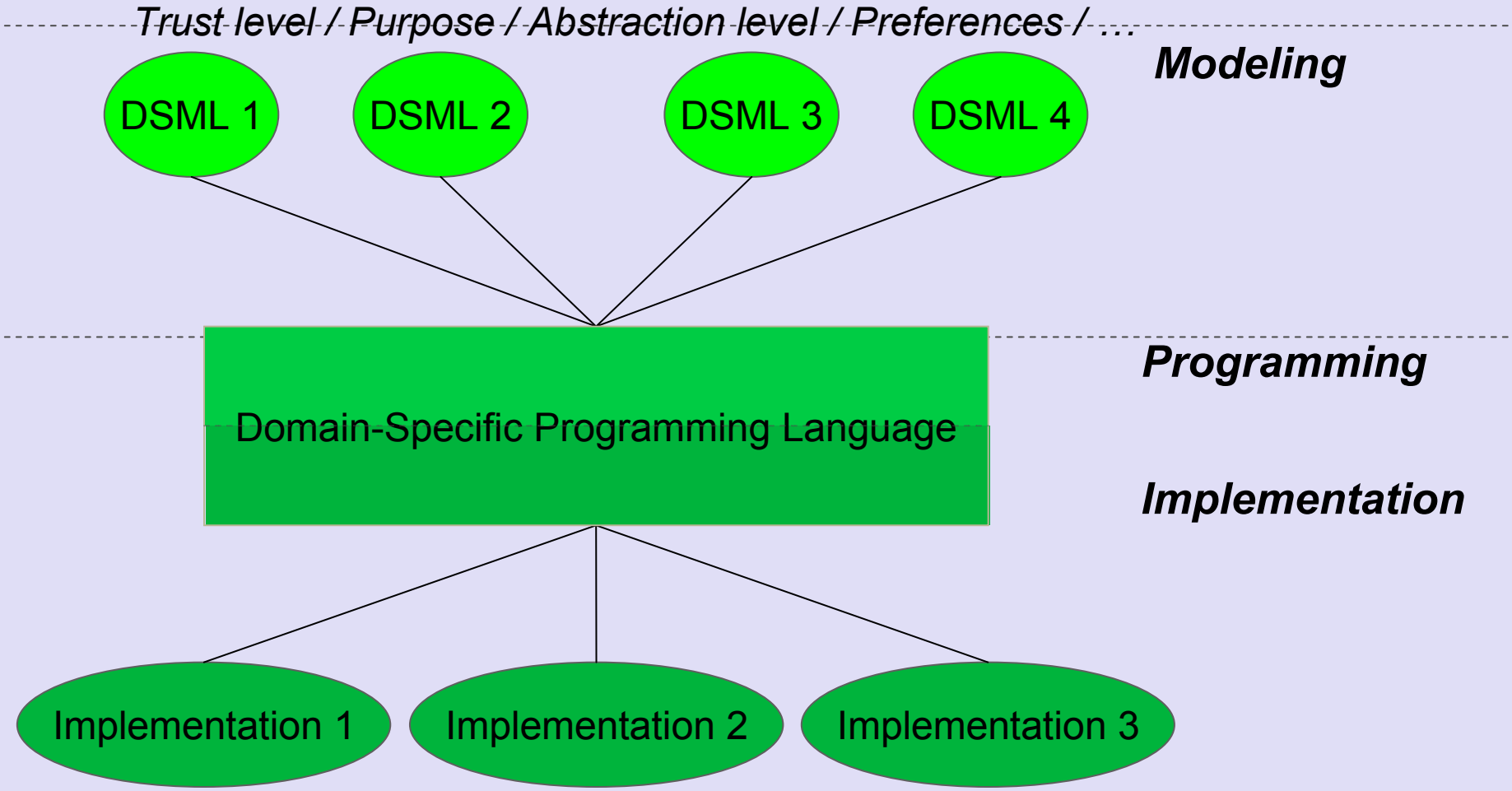


A CPL Telephony Service




```
<?xml version="1.0" encoding="UTF-8"?>
<cpl>
 <incoming>
  <location url="sip:bob@phone.example.com">
   <proxy>
    <busy>
     <location url="sip:bob@voicemail.example.com">
      <proxy />
    </busy>
    <otherwise>
     <address-switch field="origin">
      <address is="sip:boss@example.com">
       <location url="tel:+19175554242">
        <proxy />
       </location>
      </address>
     </address-switch>
    </otherwise>
   </proxy>
  </location>
 </incoming>
</cpl>
```

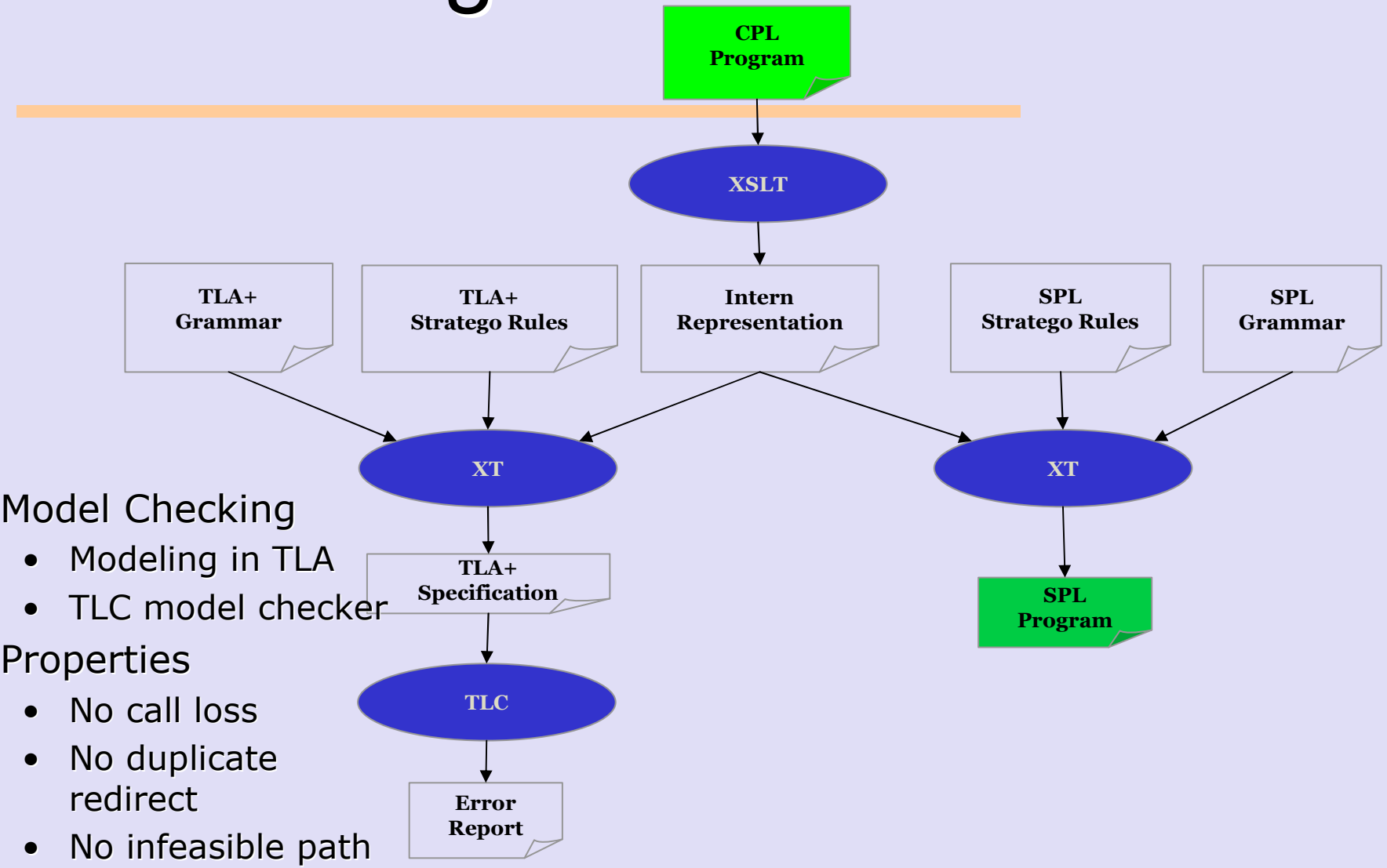
Introducing Multiple DSMLs



Processing DSMLs

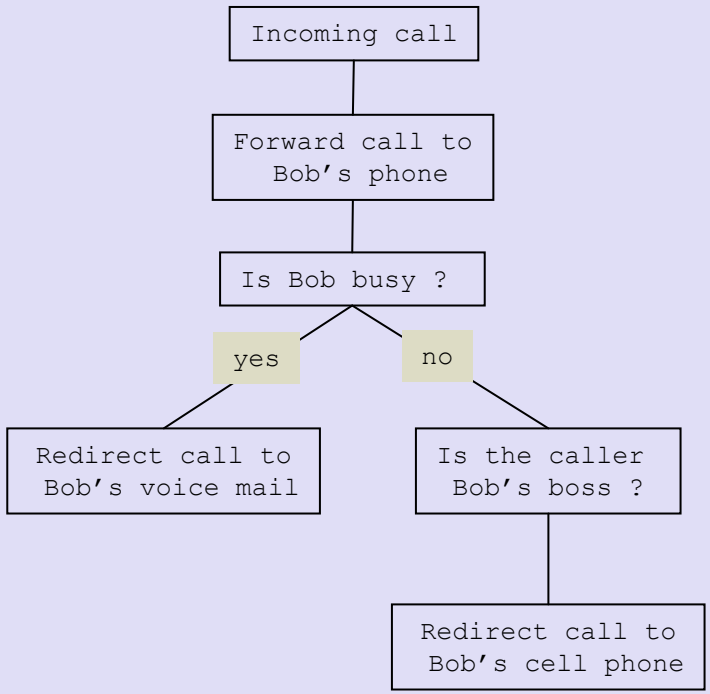
- High-level tools
- Compilation
  - DSPL Implementation
  - Formal modeling
- Verification
  - Domain-oriented properties

Processing A DSML



- Model Checking
  - Modeling in TLA
  - TLC model checker
- Properties
  - No call loss
  - No duplicate redirect
  - No infeasible path

From CPL to SPL




```
service example {
 processing {

  dialog {

   response incoming INVITE() {
    response r = forward 'sip:bob@phone.example.com';
    if (r == /ERROR/CLIENT/BUSY_HERE) {
      return forward 'sip:bob@voicemail.example.com';
    } else if (r == /ERROR) {
      if (FROM == 'sip:boss@example.com') {
        return forward 'tel:+19175554242';
      }
      return r;
    }
   }
  }
 }
}
```

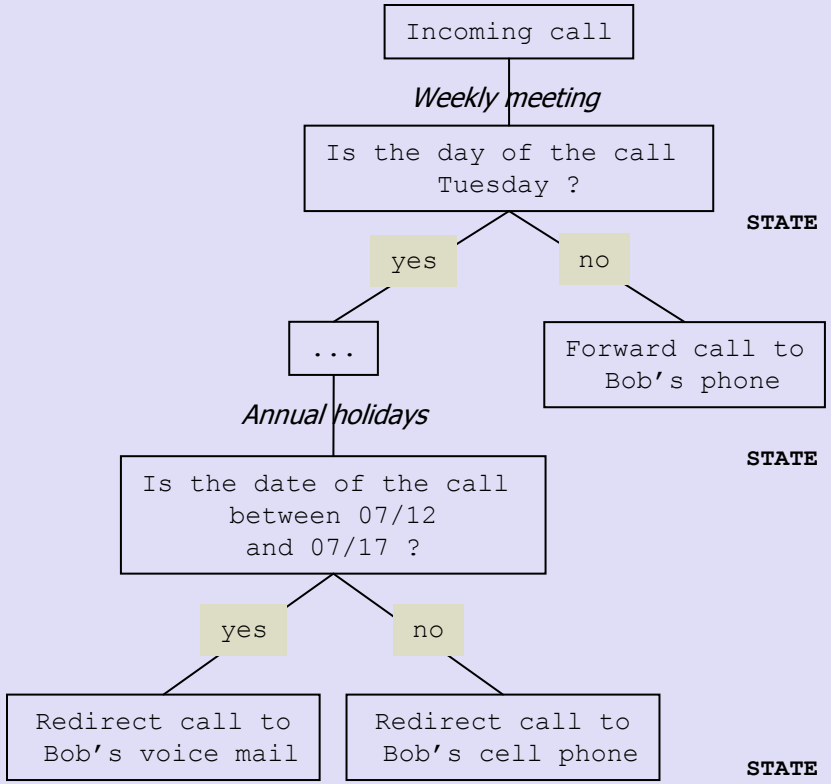
Domain-Oriented Properties

$$AtLeastOneSigAction \triangleq currentNode = \text{“End”} \Rightarrow Len(sigActions) \neq 0$$

$$NoTwiceRedirectToTheSameURI \triangleq$$
$$\Box(\forall\, n \in 1\,..\,Len(sigActions) : \forall\, m \in n+1\,..\,Len(sigActions) :$$
$$sigActions[n] \neq \text{“Continuation”} \Rightarrow sigActions[n] \neq sigActions[m])$$

$$Consistency \triangleq$$
$$\wedge\, \Box(\exists\, x \in Addresses : \forall\, n \in 1\,..\,Len(addrTest) : x \in addrTest[n])$$
$$\wedge\, \Box(date \neq \{\})$$

Checking A Telephony Service




```
TLC Version 2.0 of January 16, 2006
Model-checking
...
Finished computing initial states: 1 distinct state generated.
Error: Invariant line 143, col 23 to line 143, col 35 of module CPL is violated.
The behavior up to this point is:
STATE 1: <Initial predicate>
/\ addrTest = □ □
/\ currentNode = "Incoming"
/\ sigActions = □ □
/\ date = {[day ↦ "sun", dayNum ↦ 1, month ↦ "January"],
           ...
          [day ↦ "sun", dayNum ↦ 365, month ↦ "December"]}
STATE 2: <Action line 51, col 9 to line 53, col 60 of module CPL>
/\ addrTest = □ □
/\ currentNode = "WeeklyMeeting"
/\ sigActions = □ □
/\ date = {[day ↦ "sun", dayNum ↦ 1, month ↦ "January"],
           ...
          [day ↦ "sun", dayNum ↦ 365, month ↦ "December"]}
STATE 3: <Action line 98, col 9 to line 101, col 54 of module CPL>
/\ addrTest = □ □
/\ currentNode = "AnnualHolidays"
/\ sigActions = □ □
/\ date = {[day ↦ "tue", dayNum ↦ 3, month ↦ "January"],
           ...
          [day ↦ "tue", dayNum ↦ 192, month ↦ "July"],
          [day ↦ "tue", dayNum ↦ 199, month ↦ "July"],
           ...
          [day ↦ "tue", dayNum ↦ 360, month ↦ "December"]}
STATE 4: <Action line 110, col 9 to line 113, col 55 of module CPL>
/\ addrTest = □ □
/\ currentNode = "RedirectToBobVoiceMail"
/\ sigActions = □ □
/\ date = {}
5 states generated, 5 distinct states found, 2 states left on queue.
The depth of the complete state graph search is 4.
```

Summary

- SPL: Session Processing Language
- Contributions
  - High level abstractions and notations
    - Specific to the telephony domain
    - Ease the development process
    - Conciseness (factor of 4)
  - Performance
    - Domain-specific optimization (*e.g.*, state management)
  - Robustness
    - Critical properties guaranteed at different levels:
      - protocol, platform, and service