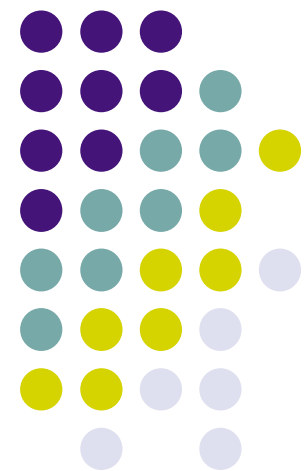
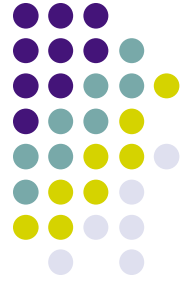


General Overview of Mozart/Oz

Peter Van Roy

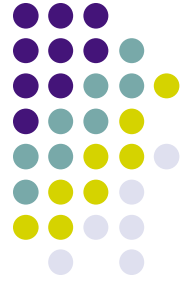
pvr@info.ucl.ac.be





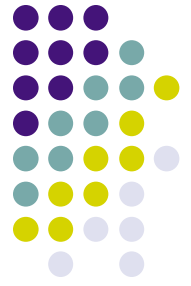
At a Glance

- Oz language
 - Dataflow concurrent, compositional, state-aware, object-oriented language
 - First-class software components and resources
- Language strengths
 - **Concurrency**: ultralightweight threads, dataflow
 - **Inferencing**: constraint and logic programming, well factored
 - **Distribution**: network transparent, open, fault tolerant
 - **Graphical user interfaces**: dynamic, adaptable
- System properties
 - Mozart: **efficient** implementation, portable, Open Source
 - Simple **formal semantics**
 - **Flexibility** with few limits, first-class compiler



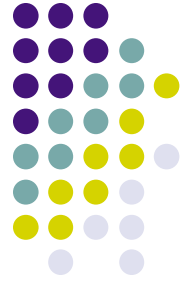
Mozart's Synergy

- Mozart has the synergy that comes from combining different areas in a deep way
 - Concurrency - constraints - distribution - flexibility - ...
- We have just started to explore the consequences of this synergy. Here are a few examples (certainly a very personal nonexhaustive list!):
 - C. Schulte's parallel search engine
 - D. Grolaux's FlexClock with flexible user interface
 - Component programming in the ICITIES project
 - Community panel in the PEPITO project (peer-to-peer)
- I encourage you to take advantage of MOZ 2004 to learn those parts you don't know yet!



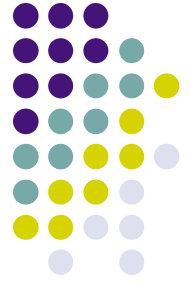
Coming to Grips with Oz

- Oz supports many programming styles, in isolation and in mixes
- Possibly you want to use more of its possibilities? Then read the following books:
 - *Concepts, Techniques, and Models of Computer Programming*, by Peter Van Roy and Seif Haridi
 - *Programming Constraint Services: High-Level Programming of Standard and New Constraint Services*, by Christian Schulte
 - *Concurrent Constraint Programming in Oz for Natural Language Processing*, by Denys Duchier, Claire Gardent, and Joachim Niehren



Areas Covered by MOZ 2004

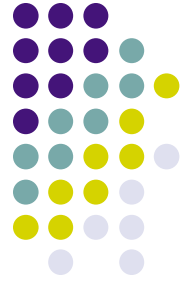
- Computer science education
- Software engineering
- Human-computer interfaces and the Web
- Distributed programming
- Grammars and natural language
- Constraint research
- Constraint applications



Invited Talks

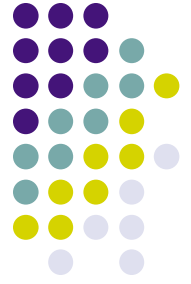
- *The Development of Oz/Mozart*
by Gert Smolka

- *The Structure of Authority: Why Security is Not a Separable Concern*
by Mark S. Miller (speaker), Bill Tulloh, and Jonathan Shapiro



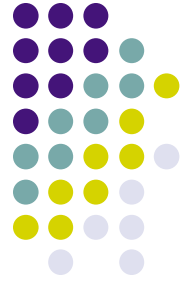
Strengths

- Strengths
 - Concurrency
 - Inferencing
 - Distribution
 - Graphical user interfaces
 - Components and agents
 - Formal semantics
- Let's take a look at some of these strengths



Concurrency (1)

- Lightweight threads
 - Preemptive scheduling with guaranteed CPU share
 - More than 100000 active threads on standard PC
- Dataflow synchronization makes concurrency easy
- Better programming techniques are possible
 - Create a thread whenever the design requires it
 - For example, a thread can be created for each active entity in a multi-agent system



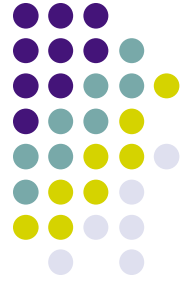
Concurrency (2)

- Declarative concurrency
 - No race conditions (deterministic)!
 - Programs calculate as purely functional programs, but incrementally
 - In most programs, the nondeterministic part can be limited to a small part of the program, keeping the advantages of declarative concurrency for the most part
 - The default execution strategy is eager evaluation, but lazy evaluation is also supported with explicit declarations
- Message-passing concurrency
 - Ideal for programming multi-agent systems
 - Programming techniques of Erlang can be used



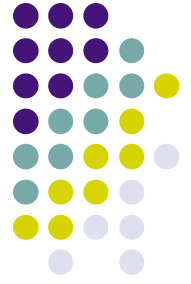
Inferencing

- Constraint programming factorizes three concepts
 - **Distribution strategy**: what constraints define the search tree (problem dependent)
 - **Search strategy**: how the search tree is traversed (problem independent)
 - **Constraint domain**
- Supports full compositionality, concurrency, laziness, and higher-order programming techniques
 - Important for structuring large programs
- Supports four constraint domains: integers (finite domains), finite sets, rational trees, real intervals
- Logic programming
 - A special case of constraint programming; supports rational trees, Andorra style nondeterminism, and deep guards
 - In my view, Oz is the de facto Next Logic Programming Language

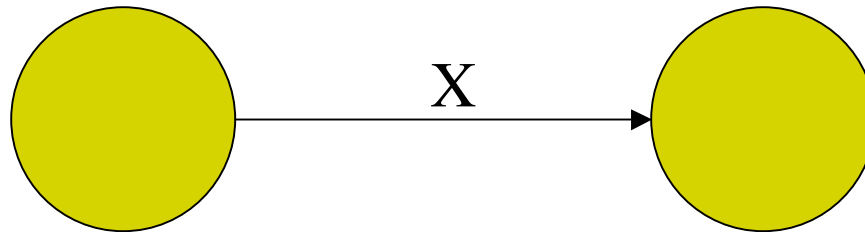


Distribution

- **Network transparent:** same language semantics obeyed independent of distribution structure
 - Program can be distributed in various ways without rewriting the bulk of the code
- **Network aware:** efficient distributed protocols implement distributed entities
 - Language classifies entities as stateful, single assignment, and stateless
 - Language is stateless by default; using state requires explicit declaration
- **Open:** any language reference can be given to any process through the concept of “ticket”
- **Robust:** failure detection within the language



Stream Communication with Dataflow Concurrency



$X = \text{all} \mid \text{roads} \mid Y$

$Y = \text{lead} \mid \text{to} \mid Z$

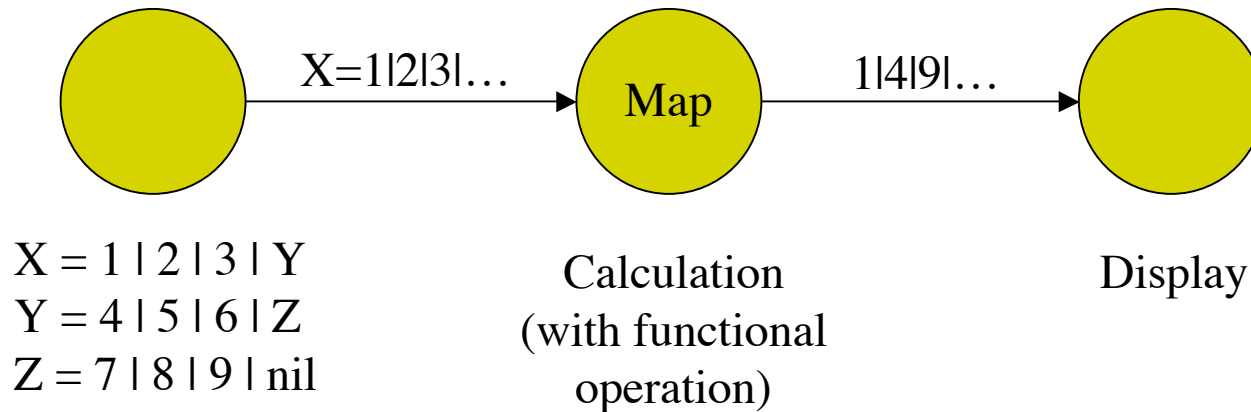
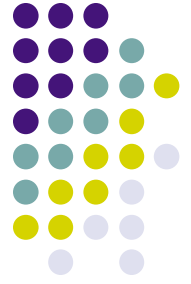
$Z = \text{alexandria} \mid \text{nil}$

Display

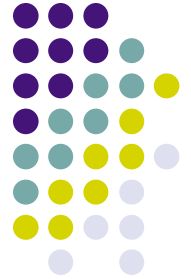
(with Browse tool)

- There are two threads
- The first thread creates the stream X incrementally
- The second thread displays it using dataflow
- Transmission is **asynchronous** (like a pipe)

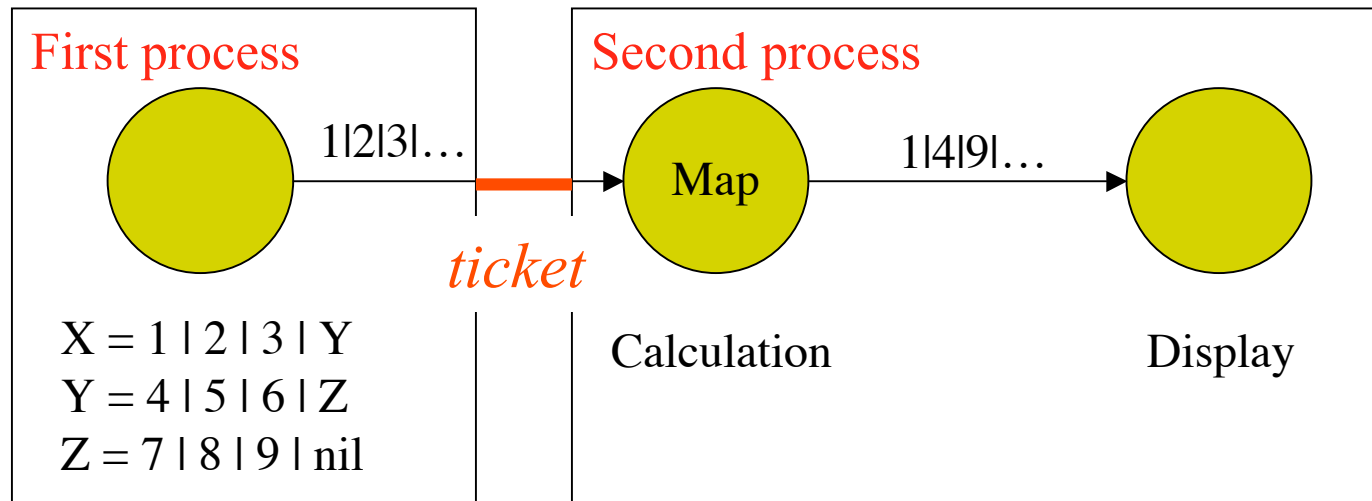
Stream Communication with Dataflow Concurrency



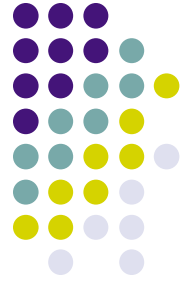
- There are three threads
- The first thread creates a stream of data
- The second thread does a calculation
- The third thread displays the results



Stream Communication with Dataflow Concurrency



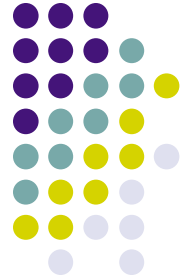
- Exactly the same thing, but *distributed*
- The processes connect through a *ticket*
 - A ticket is a reference that can exist outside of a process (since it is coded as an Ascii string)
- Except for the ticket, the program is unchanged



Graphical User Interfaces

- Mixed declarative/imperative approach to GUI design, as realized in the QtK tool
 - Declarative specification is a data structure; can be manipulated easily
 - Interface structure, widget types, initial state, resize behavior
 - Imperative specification is a program; has maximum expressiveness
 - Action procedures and handler objects embedded in the data structure
- This makes creating **dynamic interfaces** easy

Example User Interface



Nested record with handler object E and action procedure P

```
W=td(lr(label(text:«Enter your name»)  
      entry(handle:E) )  
      button(text:«Ok» action:P))
```

Construct interface (window & handler)

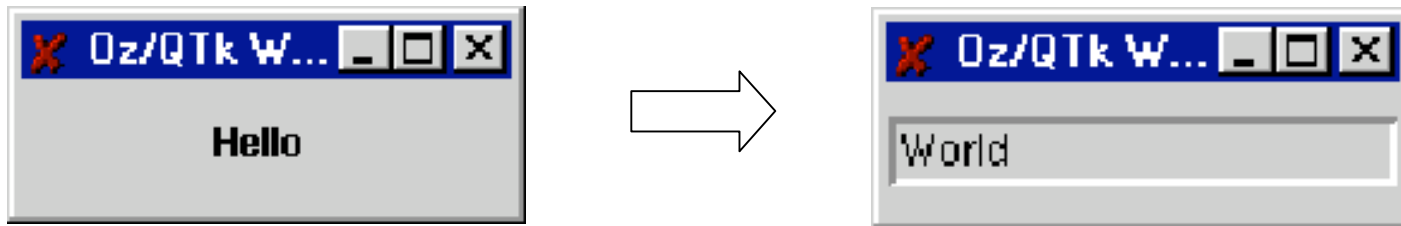
```
...  
{Qt.build W}  
...  
{E set(text:«Type here») }
```

Call handler

```
...  
Result={E get(text:$) }
```



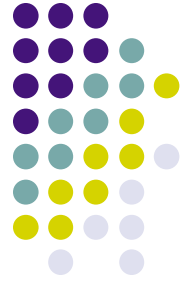

Example Dynamic Interface



```
W=placeholder(handle:P)
...
{P set(label(text:«Hello»)}
...
{P set(entry(text:«World»)}
}
```

- Any GUI specification can be put in the placeholder at run-time
- GUIs specifications are data structures; can be calculated

The Right Default: Concurrent Components



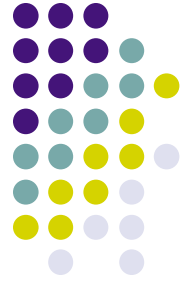
- In our experience, the right default for structuring programs is as concurrent components that communicate through asynchronous message passing
 - Not a new idea; Carl Hewitt anticipated it **30 years ago!** But now we understand it very well.
- Unfortunately, this is almost universally ignored by mainstream languages and books on program design
 - Object-oriented programming and shared-state concurrency are given priority, even though they are the **wrong default**

Mozart Support for Concurrent Components



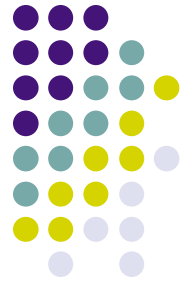
- The Mozart platform supports this default well
 - Ultralightweight threads
 - Support for message-passing concurrency
 - Note that there are no built-in monitors in Oz!
 - Isn't it strange? Not at all!
- We strongly recommend that you take advantage of this support to structure your applications!

Three Reasons Why Concurrent Components are the Right Default

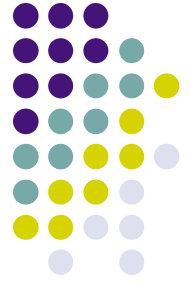


1. The simplest paradigms for concurrent programming are declarative concurrency and message-passing concurrency
 - Compare *Concurrent Programming in Erlang* with *Concurrent Programming in Java*
2. The **Erlang** language and system is used successfully for building highly available systems; for fundamental reasons it uses this model
3. The **E** language and system is used successfully for building secure distributed systems; again for fundamental reasons it uses this model

The Exaggerated Importance of Object-oriented Programming



- Consider for example the task of building robust telecommunications systems
- Ericsson has developed an extremely reliable ATM switch (the AXD 301) using a message-passing architecture
- The important concepts are **isolation**, **concurrency**, and **higher-order programming**
- Not used: **inheritance**, **classes**, **methods**, **UML diagrams**, and **monitors**
 - Maybe these concepts are not the essential ones?



Formal Semantics

- Oz has a simple formal semantics
 - Well factored Structural Operational Semantics for the complete Oz kernel language (e.g., chapter 13 of Oz book)
 - Operational semantics is subsettable for all paradigms
 - Other semantics (denotational, axiomatic, logical) for particular subsets that make this easy
- Mozart is designed to implement the semantics
 - The mere existence of a simple semantics, even if ignored by the programmer, means that there are no unexpected surprises
 - The system is both simple and highly expressive

Programming Languages and Paradigms



Declarative programming

strict functional programming, e.g., Scheme, ML

deterministic logic programming

+ **concurrency**

+ **by-need synchronization**

declarative concurrency

lazy functional programming, e.g., Haskell

+ **nondeterministic choice**

concurrent logic programming

+ **exception handling**

+ **explicit state**

object-oriented programming

+ **search**

nondeterministic LP, e.g., Prolog

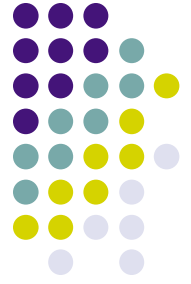
concurrent OOP

(active object style, e.g., Erlang)

(shared state style, e.g., Java)

+ **computation spaces**

constraint programming



Conclusions

- The Mozart/Oz platform covers a lot of ground in a coherent way
- We hope that MOZ 2004 inspires you to cover more of this ground and take advantage of what Mozart/Oz offers
- Enjoy the conference!