C++ and Beyond

Meyers Sutter Alexandrescu

December 13-16, 2010

Snoqualmie
Washington
USA

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C++ and Beyond 2010 *Sample*

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C++ and Beyond

Snoqualmie, Washington, USA
October 24-27, 2010

Schedule

	Sunday	Monday	Tuesday	Wednesday
8:00 - 9:00		**Group Breakfast** [Attic]	**Group Breakfast** [Attic]	**Group Breakfast** [Attic]
9:00 - 10:30		**Welcome** [Andrei] **Move Semantics, Rvalue References, and Perfect Forwarding, Part 1** [Scott]	**A Fresh Look at Containers and Iterators** [Andrei]	**Elements of Design, Part 1** [Herb]
		Break	Break	Break
10:45 - 12:00		**Move Semantics, Rvalue References, and Perfect Forwarding, Part 2** [Scott]	**CAS-Based Concurrency** [Andrei]	**Elements of Design, Part 2** [Herb]
12:00 - 2:30		**Group Lunch and Mid-Day Activity**	**Group Lunch and Mid-Day Activity**	**Group Lunch and Mid-Day Activity**
2:30 - 3:45		**Lambdas, Lambdas, Everywhere** [Herb]	**CPU Caches and Why You Care** [Scott]	**Super Size Me: Lessons Learned Working at a Web Company** [Andrei]
		Break	Break	Break
4:00 - 5:00		**Ask us anything...in advance** [Panel]	**Points and Counterpoints** [Panel]	**Ask us anything...live!** [Panel]
5:00 - 7:30		Free Time (No Official C&B-Related Activities)		
7:30 - 9:30	**Reception** [Ballroom]	**Informal Discussions** [Falls Terrace & Ballroom]	**Informal Discussions** [Falls Terrace & Ballroom]	

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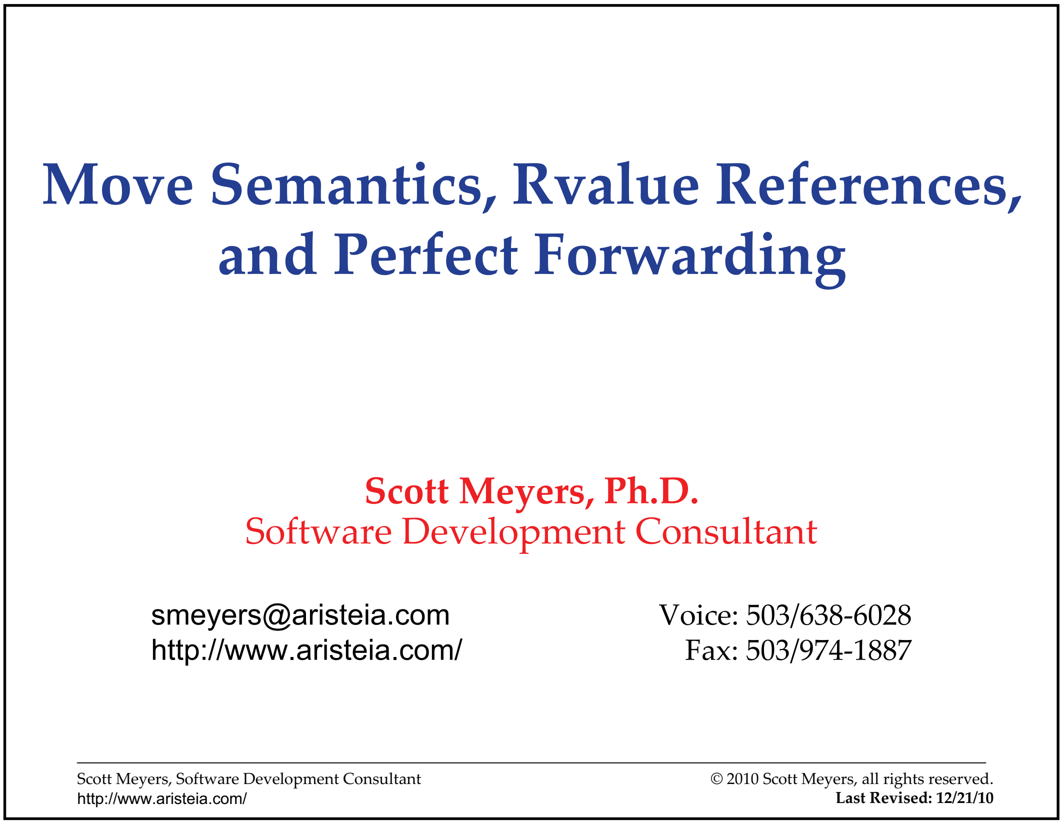
Schedule

	Monday	Tuesday	Wednesday	Thursday
8:00 - 8:45		**Group Breakfast** [Attic]	**Group Breakfast** [Attic]	**Group Breakfast** [Attic]
8:45 - 9:00		**Welcome**	**Announcements**	**Announcements**
9:00 - 10:30		**Move Semantics, Rvalue References, and Perfect Forwarding, Part 1** [Scott]	**Elements of Design, Part 1** [Herb]	**Scalable Use of the STL** [Andrei]
		Break	Break	Break
10:45 - 12:00		**Move Semantics, Rvalue References, and Perfect Forwarding, Part 2** [Scott]	**CAS-Based Concurrency** [Andrei]	**Elements of Design, Part 2** [Herb]
12:00 - 2:30		**Group Lunch** **and** **Mid-Day Activity**	**Group Lunch** **and** **Mid-Day Activity**	**Group Lunch** **and** **Mid-Day Activity**
2:30 - 4:00		**Lambdas, Lambdas, Everywhere** [Herb]	**CPU Caches and Why You Care** [Scott]	**Super Size Me: Lessons Learned Working at a Web Company** [Andrei]
		Break	Break	Break
4:15 - 5:00		**Informal C++0x Feature Overview** [Scott, Herb, Andrei]	**Q&A** [Andrei, Scott, Herb]	**Q&A** [Herb, Andrei, Scott]
5:00 - 7:30		Free Time (No Official C&B-Related Activities)		
7:30 - 9:30	**Reception** [Falls Terrace]	**Informal Discussions** [Falls Terrace]	**Informal Discussions** [Falls Terrace]	



Move Semantics, Rvalue References, and Perfect Forwarding

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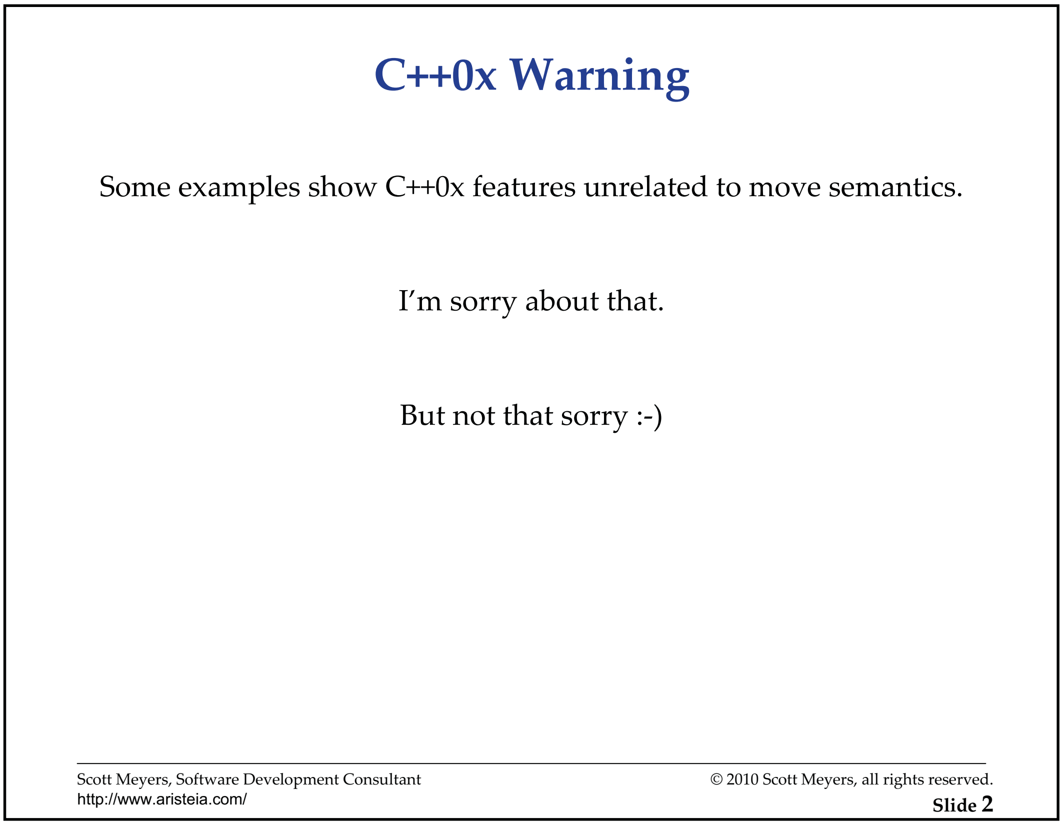
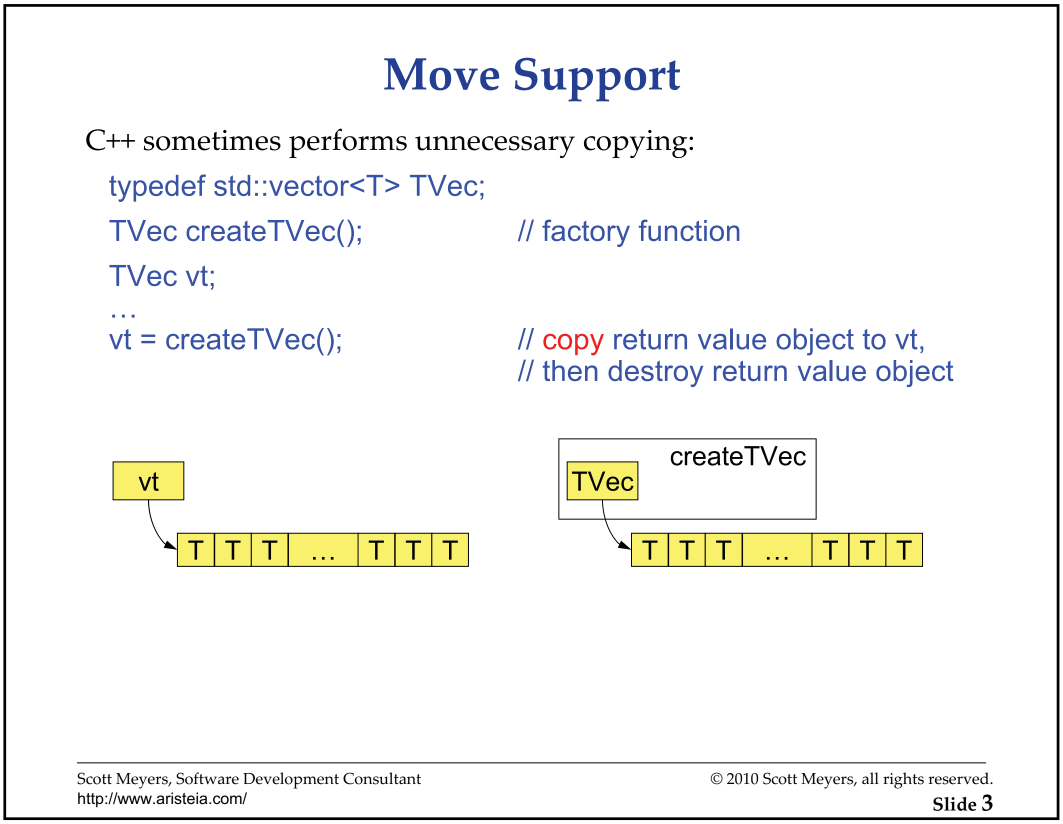


C++0x Warning

Some examples show C++0x features unrelated to move semantics.

I'm sorry about that.

But not that sorry :-)

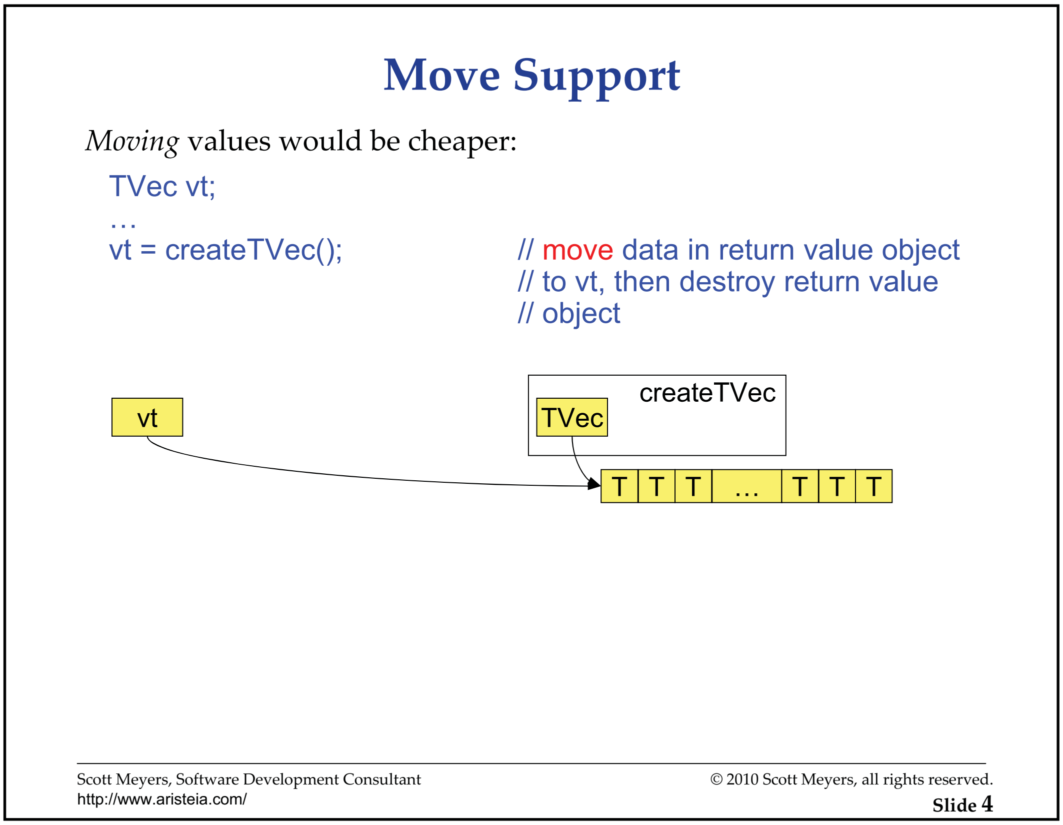


Move Support

C++ sometimes performs unnecessary copying:

```
typedef std::vector<T> TVec;
TVec createTVec();              // factory function
TVec vt;
…
vt = createTVec();              // copy return value object to vt,
                                // then destroy return value object
```

vt
T T T … T T T
createTVec
TVec
T T T … T T T

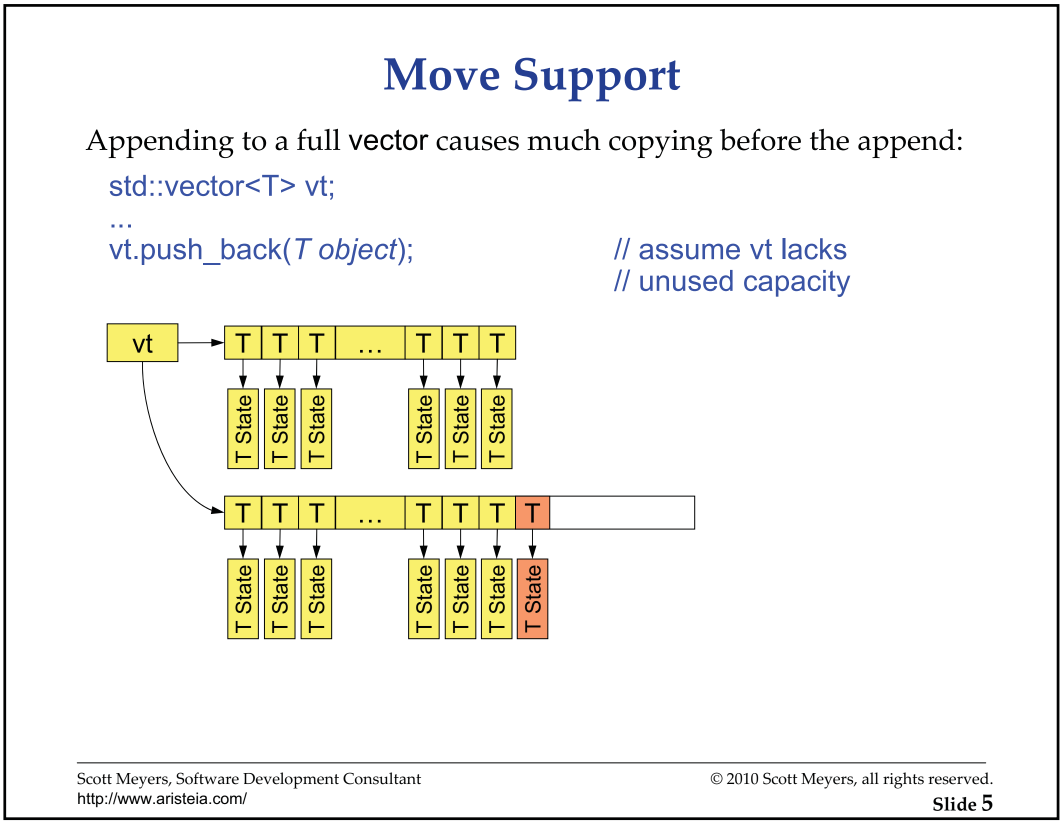


Move Support

Moving values would be cheaper:

```
TVec vt;
…
vt = createTVec();              // move data in return value object
                                // to vt, then destroy return value
                                // object
```

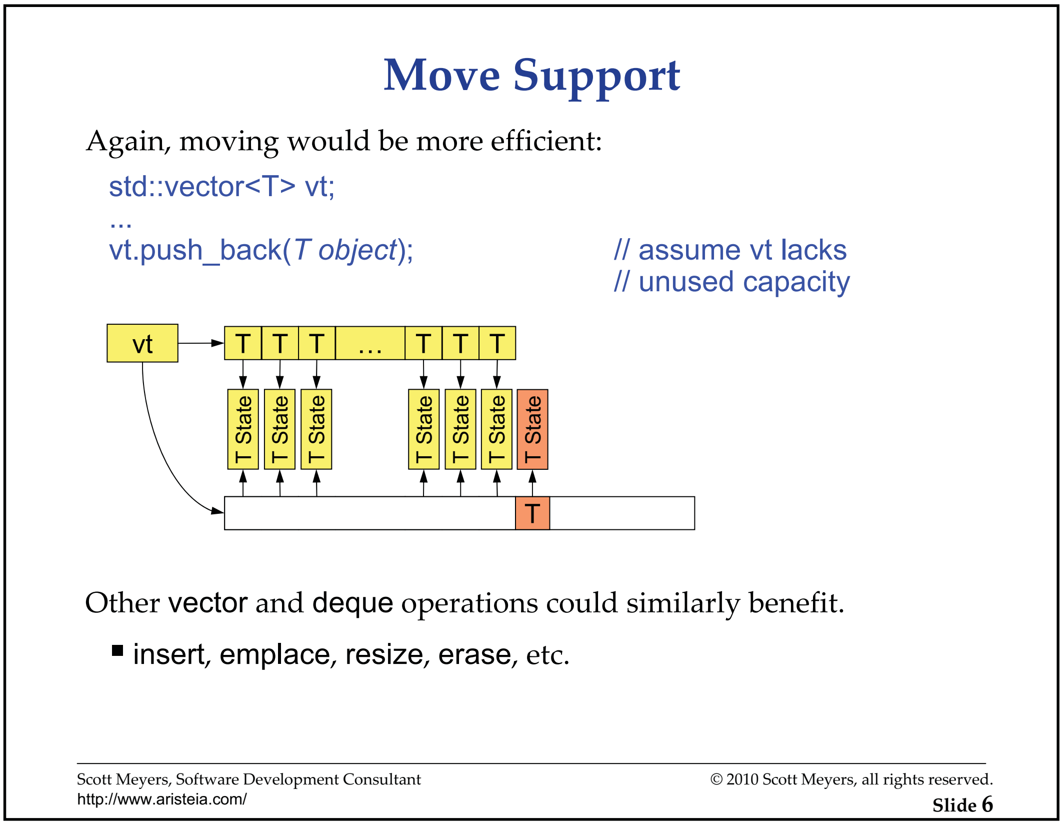
vt
createTVec
TVec
T T T … T T T



Move Support

Appending to a full vector causes much copying before the append:

```
std::vector<T> vt;
...
vt.push_back(T object);                 // assume vt lacks
                                        // unused capacity
```



Move Support

Again, moving would be more efficient:

```
std::vector<T> vt;
...
vt.push_back(T object);                 // assume vt lacks
                                        // unused capacity
```

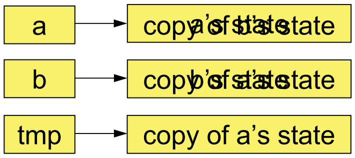
Other vector and deque operations could similarly benefit.

- insert, emplace, resize, erase, etc.

Move Support

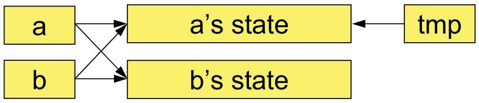
Still another example:

```
template<typename T>          // straightforward std::swap impl.
void swap(T& a, T& b)
{
  T tmp(a);                   // copy a to tmp (⇒ 2 copies of a)
  a = b;                      // copy b to a (⇒ 2 copies of b)
  b = tmp;                    // copy tmp to b (⇒ 2 copies of tmp)
}                             // destroy tmp
```

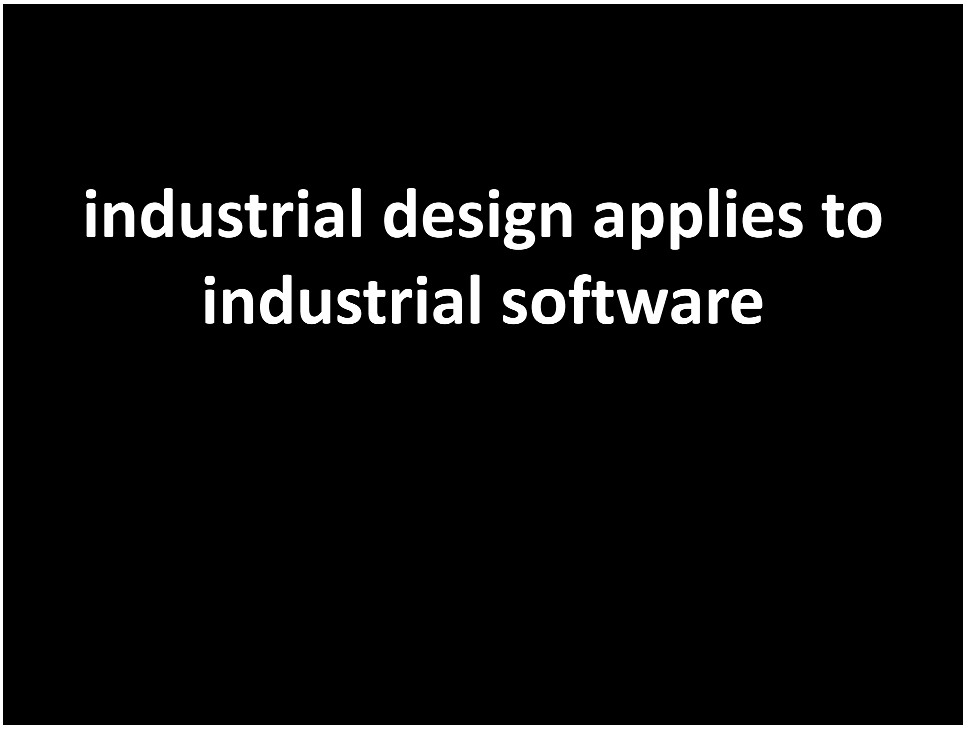


Move Support

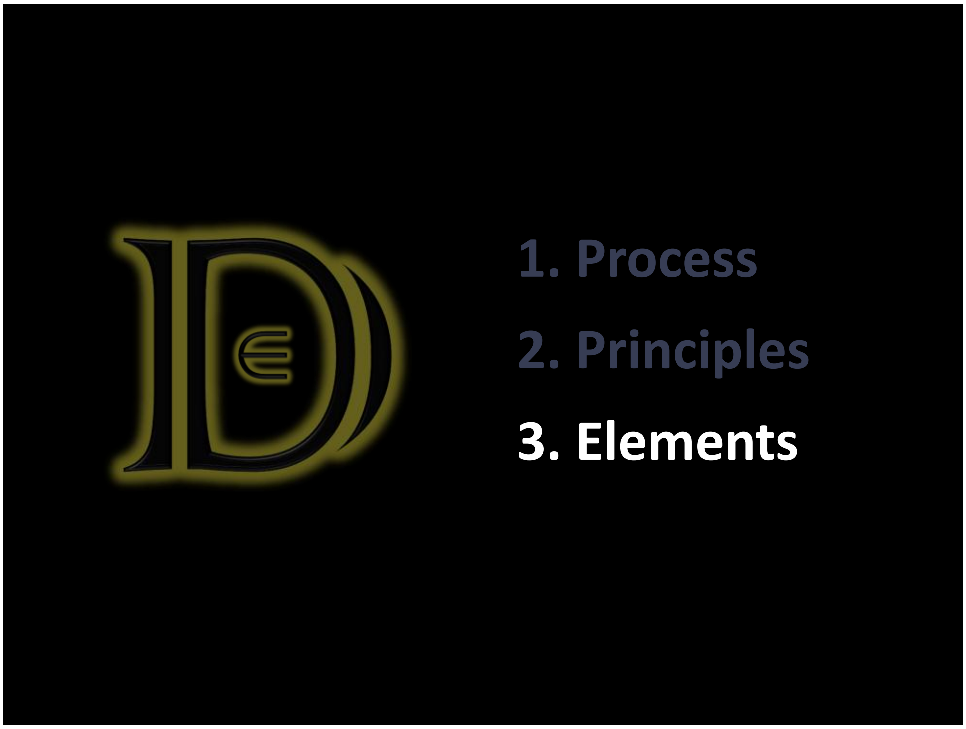
```
template<typename T>          // straightforward std::swap impl.
void swap(T& a, T& b)
{
  T tmp(std::move(a));        // move a's data to tmp
  a = std::move(b);           // move b's data to a
  b = std::move(tmp);         // move tmp's data to b
}                             // destroy (eviscerated) tmp
```



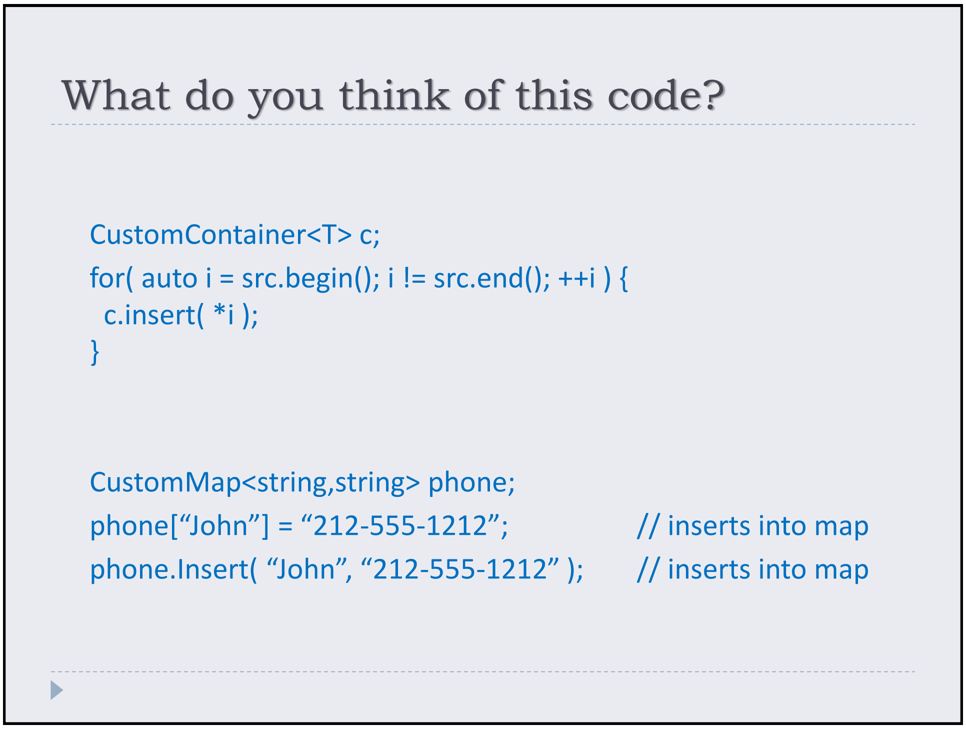
Herb Sutter



industrial design applies to industrial software



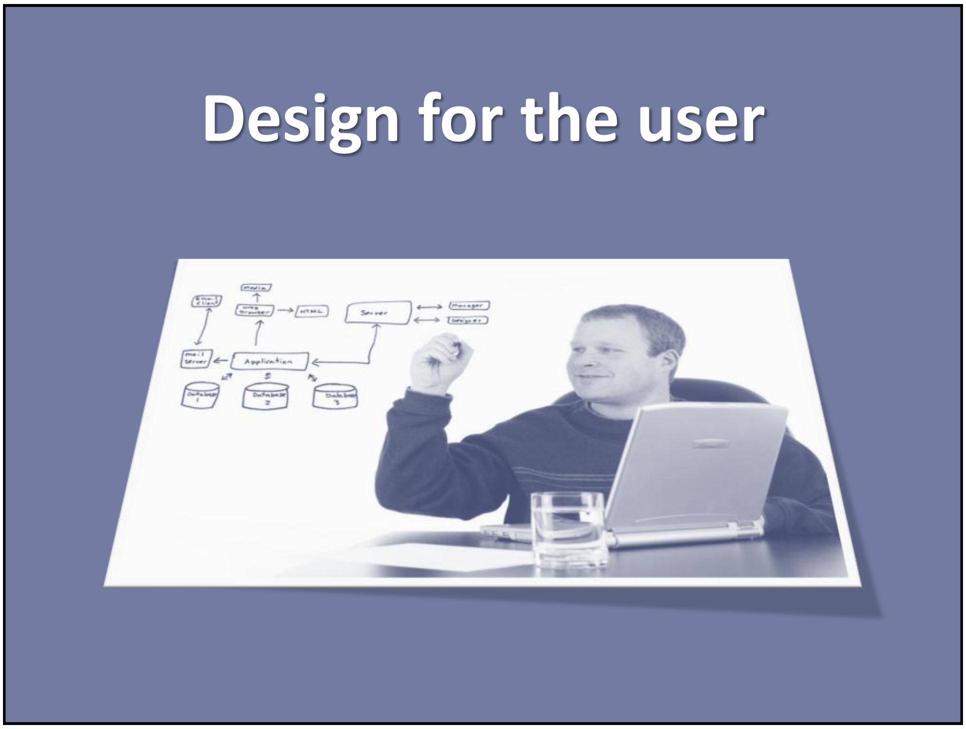
1. Process
2. Principles
3. Elements



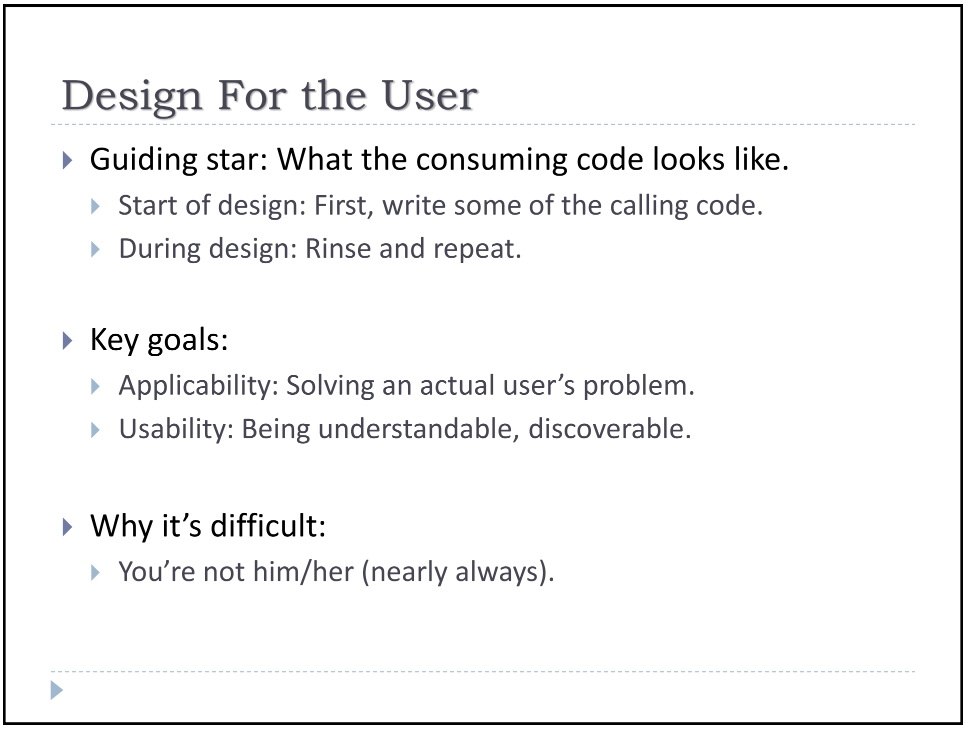
What do you think of this code?

```
CustomContainer<T> c;
for( auto i = src.begin(); i != src.end(); ++i ) {
  c.insert( *i );
}


CustomMap<string,string> phone;
phone[“John”] = “212-555-1212”;               // inserts into map
phone.Insert( “John”, “212-555-1212” );       // inserts into map
```

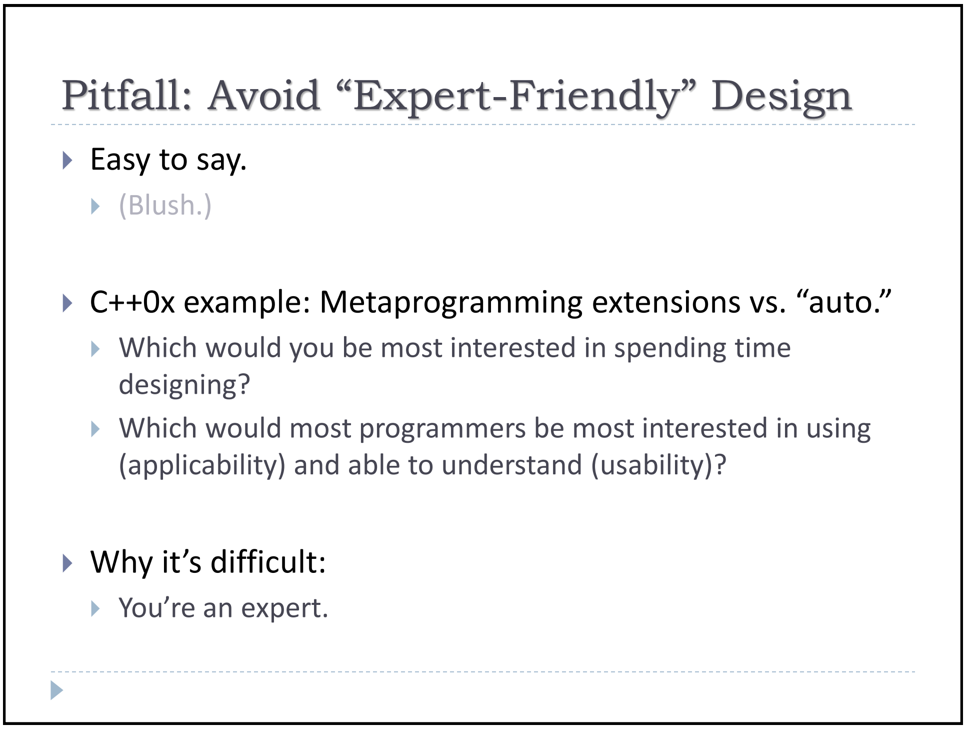


Design for the user



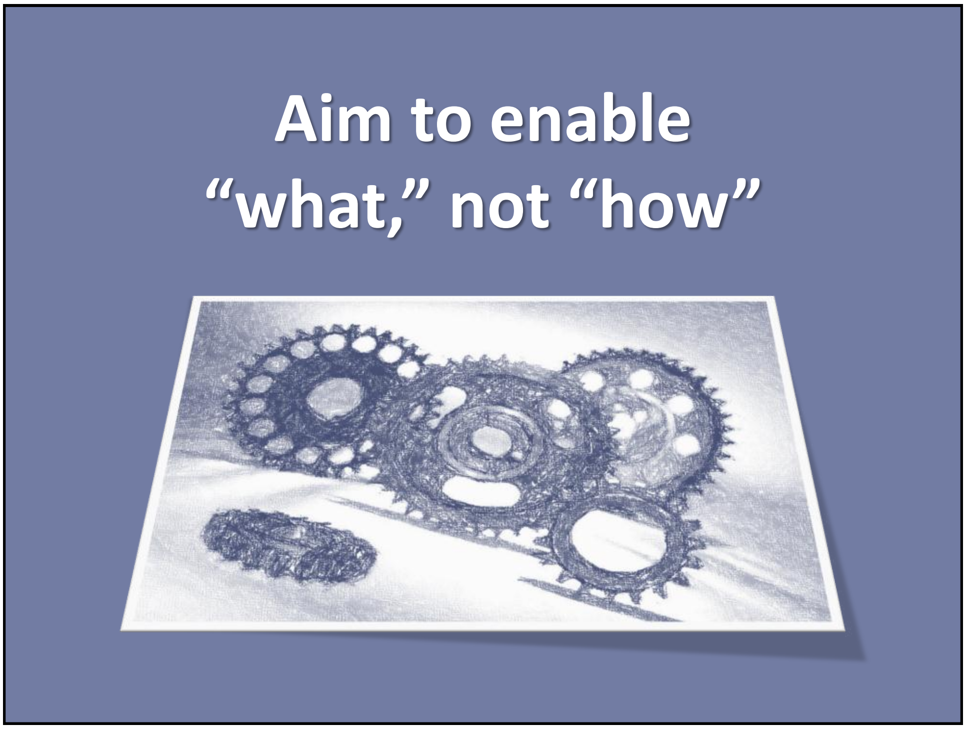
Design For the User

- Guiding star: What the consuming code looks like.
  - Start of design: First, write some of the calling code.
  - During design: Rinse and repeat.
- Key goals:
  - Applicability: Solving an actual user’s problem.
  - Usability: Being understandable, discoverable.
- Why it’s difficult:
  - You’re not him/her (nearly always).



Pitfall: Avoid “Expert-Friendly” Design

- Easy to say.
  - (Blush.)
- C++0x example: Metaprogramming extensions vs. “auto.”
  - Which would you be most interested in spending time designing?
  - Which would most programmers be most interested in using (applicability) and able to understand (usability)?
- Why it’s difficult:
  - You’re an expert.



Aim to enable “what,” not “how”

CAS-Based Concurrency

Prepared for C++ and Beyond 2010

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This Talk

- Lock-free programming: Brief history and introduction
- CAS-based code
- A Singly-Linked Lock-Free List

Motto

“Multithreading is just one darn thing after, before, or simultaneously with another”.

Lock-free Programming: Brief History and Introduction

Defining Terms

- *Wait-free procedure:* completes in a bounded number of steps regardless of the relative speeds of other threads
- *Lock-free procedure:* at any time, at least one thread is guaranteed to make progress
  - Probabilistically, all threads will finish timely
- Mutex-based procedures
  - Not wait-free
  - Not lock-free

A Different Angle

- *Lock-based:* ask for synchronization device prior to operation
- Pessimistically assumes contention

- *Wait/Lock-free:* Perform operation, attempt to commit
- Optimistically assumes no contention
- “Better ask for forgiveness than permission”

Brief History

- Lock-based threading theory established in the 1960s
  - Still the dominant model today
- By 1972—efforts to avoid mutex-based pessimistic concurrency control
  - Atomic assignment
  - Use of atomic instructions: increment, test-and-set
- By 1990—search for universal atomic primitive that would enable all others
- 1991: “Wait-free synchronization” by Herlihy settles the matter

Impossibility/Universality

- Some primitives cannot synchronize any shared data structure for >2 threads
  - test-and-set
  - fetch-and-add
  - atomic queues!
- Some other primitives are enough to implement any shared data structure
  - e.g., CAS