Advanced Programming

ACSE-5: Lecture 3

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Overview

- Create objects
- STL library
- Debug

- We start by looking at many interconnected concepts that will advance your understanding of object orientated libraries
- True understanding will require additional reading (homework) and independent coding
- This class tries to marry different levels of progression catering for starting and intermediate level programmers

Objects

- These are ways of creating new types beyond the native types

- Create objects:
  - class
  - enum
  - typedef
  - And… templates

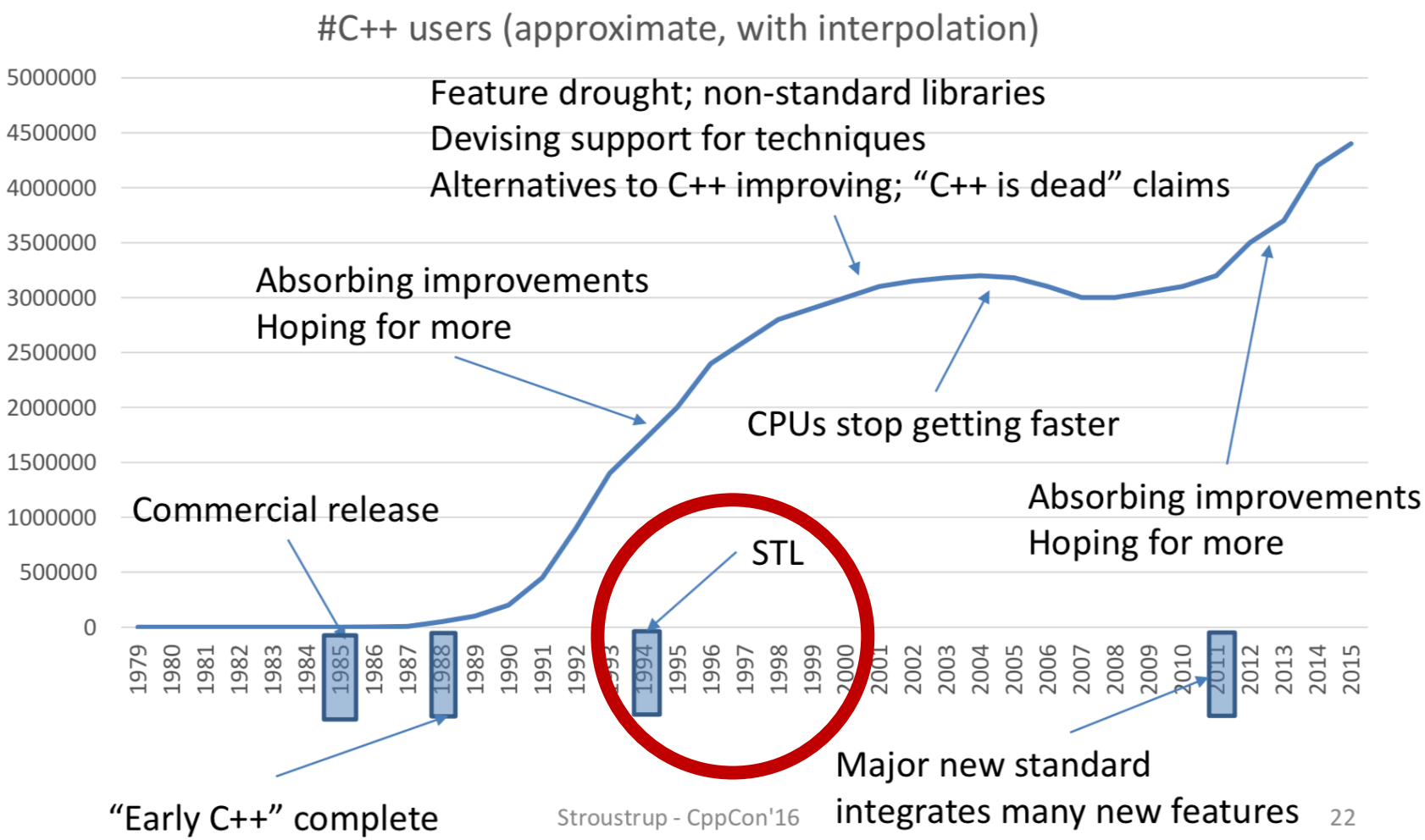
  These are “typename”s.

from the c++ grammar

simple-type-specifier:	
	::opt nested-name-specifieropt type-name
	::opt nested-name-specifier **template** simple-template-id
	char
	char16_t C++0x
	char32_t C++0x
	wchar_t
	bool
	short
	int
	long
	signed
	unsigned
	float
	double
	void
	auto C++0x
	decltype-specifier C++0x
type-name:	
	class-name
	enum-name
	typedef-name
	simple-template-id C++0x
decltype-specifier:	
	decltype (expression) C++0x

http://www.nongnu.org/hcb/

“C++ Success” by Bjarne Stroustrup



The Standard Template Library, or STL

STL is a C++ library of container classes, algorithms, and iterators;

it provides many of the basic algorithms and data structures of computer science.

The STL is a generic library, meaning that its components are heavily parameterized: almost every component in the STL is a template.

You should make sure that you understand how templates work in C++ before you use the STL.

-SGI Introduction to the Standard Template Library

STL Library

- Code reuse, abstraction and optimization of containers and algorithms
- Efficient (fast and less resources)
- Accurate (less bugs)
- Readable code
- Standardised
- A good example of what a library should be

Types of Containers

- Sequence containers (arrays and linked lists)
  - Vector, deque, list, forward list
- Associative containers (binary tree)
  - Set, multiset
  - Map, multimap
- Unordered containers (hash table)
  - Unordered set/multiset
  - Unordered map/multimap

Sequence Containers

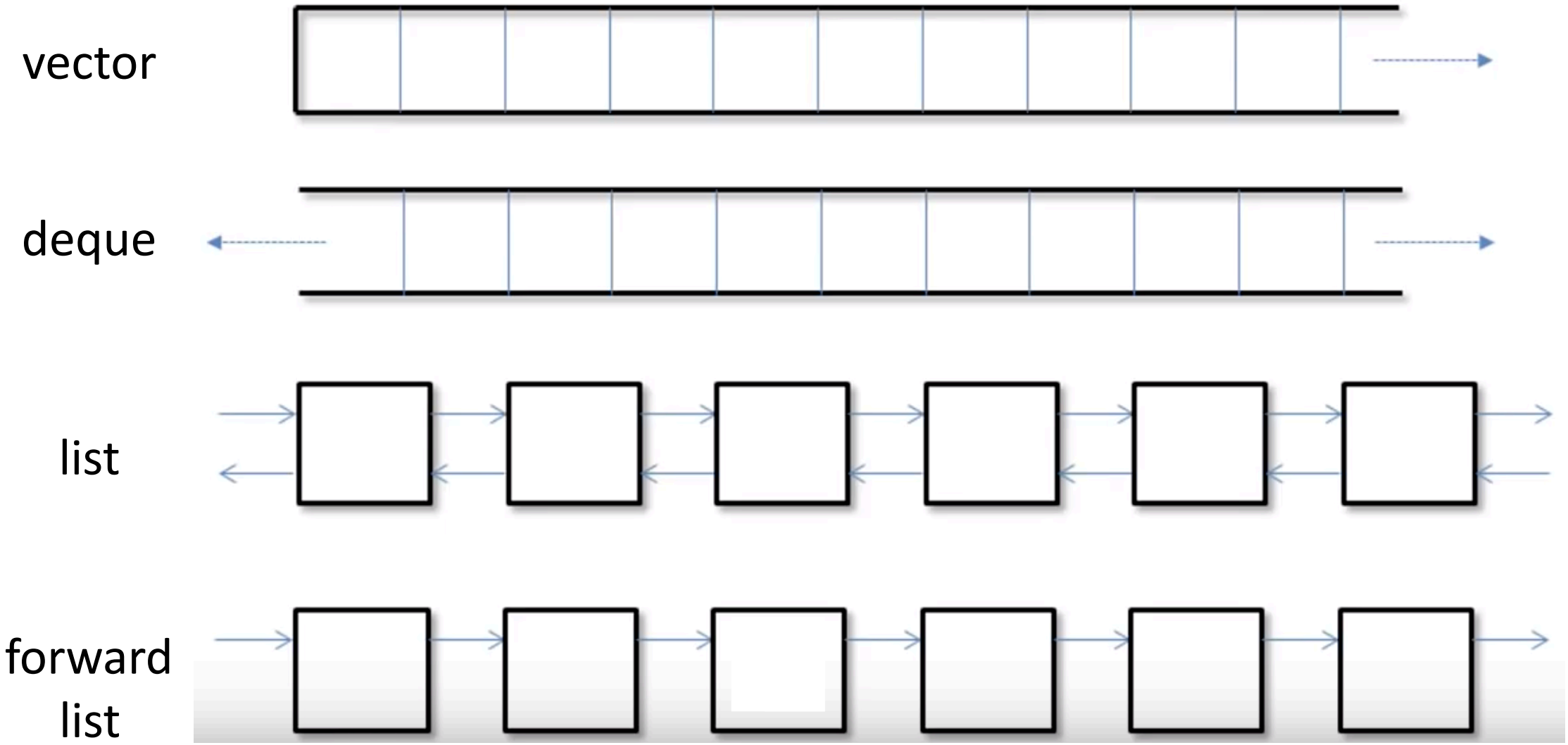
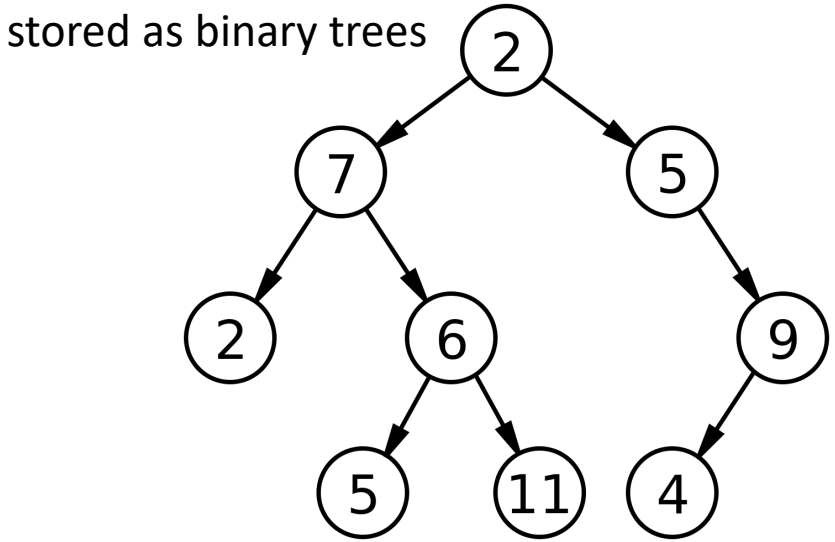
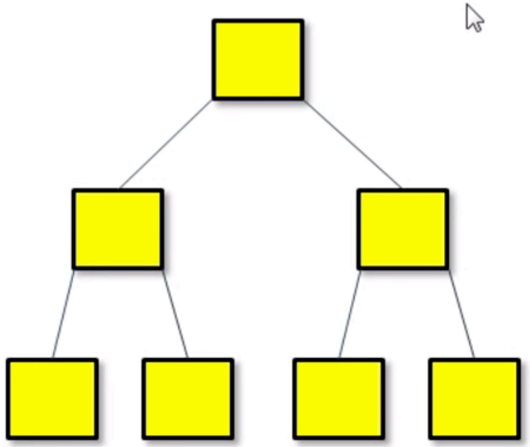


Image taken from Bo Qian's YouTube "Introduction of STL 3: Sequence Containers"

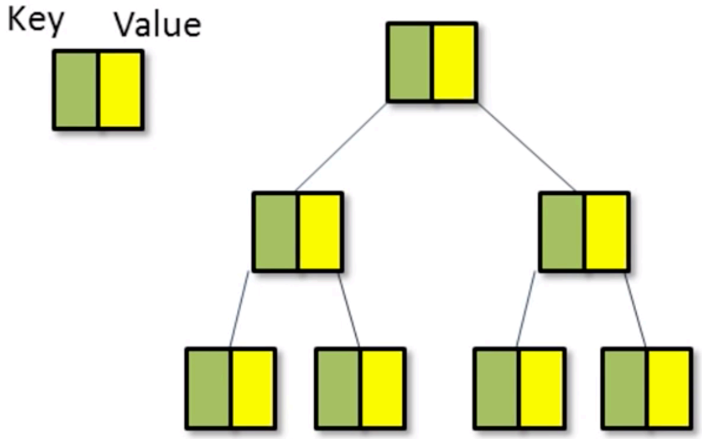
Associative Containers



Set or Multiset:



Map or Multimap:



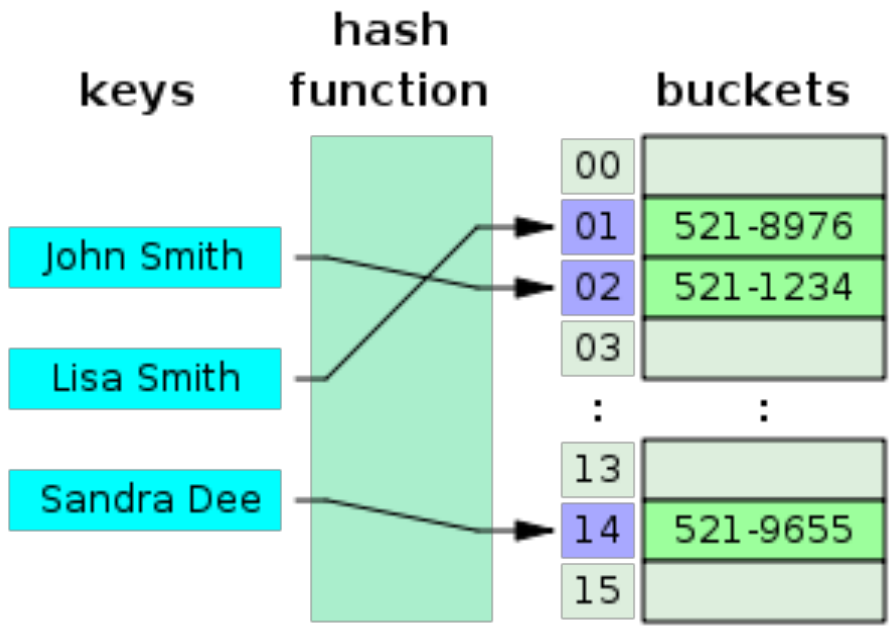
The underlying data structure is a balanced search tree:

- logarithmic access time
- requires order comparisons of keys
- iteration in key order
- Iterators, pointers and references stay valid until the pointed to element is removed.

Image taken from Bo Qian's YouTube "Introduction of STL 3: Associative Containers"

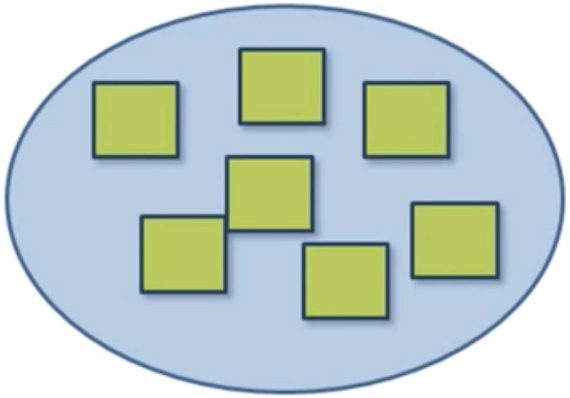
Unordered Containers

Stored using hash tables:



search, insert and delete in constant time

Unordered
Set or Multiset:



Unordered
Map or Multimap:

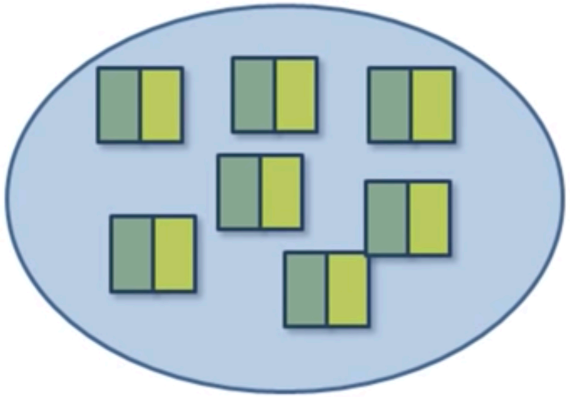


Image taken from Bo Qian's YouTube "Introduction of STL 4: Unordered Containers"

Containers have different benefits and costs

	Array	**Vector**	**Deque**	**List**	**Forward List**	**Associative Containers**	**Unordered Containers**
Available since	TR1	C++98	C++98	C++98	C++11	C++98	TR1
Typical internal data structure	Static array	Dynamic array	Array of arrays	Doubly linked list	Singly linked list	Binary tree	Hash table
Element type	Value	Value	Value	Value	Value	Set: value Map: key/value	Set: value Map: key/value
Duplicates allowed	Yes	Yes	Yes	Yes	Yes	Only multiset or multimap	Only multiset or multimap
Iterator category	Random access	Random access	Random access	Bidirectional	Forward	Bidirectional (element/key constant)	Forward (element/key constant)
Growing/shrinking	Never	At one end	At both ends	Everywhere	Everywhere	Everywhere	Everywhere
Random access available	Yes	Yes	Yes	No	No	No	Almost
Search/find elements	Slow	Slow	Slow	Very slow	Very slow	Fast	Very fast
Inserting/removing invalidates iterators	—	On reallocation	Always	Never	Never	Never	On rehashing
Inserting/removing references, pointers	—	On reallocation	Always	Never	Never	Never	Never
Allows memory reservation	—	Yes	No	—	—	—	Yes (buckets)
Frees memory for removed elements	—	Only with `shrink_to_fit()`	Sometimes	Always	Always	Always	Sometimes
Transaction safe (success or no effect)	No	Push/pop at the end	Push/pop at the beginning and the end	All insertions and all erasures	All insertions and all erasures	Single-element insertions and all erasures if comparing doesn't throw	Single-element insertions and all erasures if hashing and comparing don't throw

Homework

1) Investigate for each STL containers the cost of:

- Resizing
- Inserting an element (at the front, end, random location)
- Delete an element (at the front, end, random location)

2) **Read Chapters 3, 4, and 5 of** Programming: Principles and Practice using C++ by Bjarne Stroustrup (this includes an introduction to the C++ grammar)

3) ADVANCED:

What are container adaptors (such as stack queue and priority_queue? Create them and compare them to the traditional containers.

4) SUPER ADVANCED:

Compute (yourself) the overhead of each container: how much more space does the actual container occupy in addition to its contents

Homework(ish) 2

- Take the time to watch these amazing **videos** (3+ hours well spent!)

https://channel9.msdn.com/Series/C9-Lectures-Stephan-T-Lavavej-Standard-Template-Library-STL-/C9-Lectures-Introduction-to-STL-with-Stephan-T-Lavavej

https://channel9.msdn.com/Series/C9-Lectures-Stephan-T-Lavavej-Advanced-STL/C9-Lectures-Stephan-T-Lavavej-Advanced-STL-1-of-n

And more advanced: Core C++

https://channel9.msdn.com/Series/C9-Lectures-Stephan-T-Lavavej-Core-C-/Stephan-T-Lavavej-Core-C-1-of-n

THE #1 PROGRAMMER EXCUSE FOR LEGITIMATELY SLACKING OFF:

"MY CODE'S COMPILING."