Introduction to Kyoto Products

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Kyoto Cabinet

- database library -

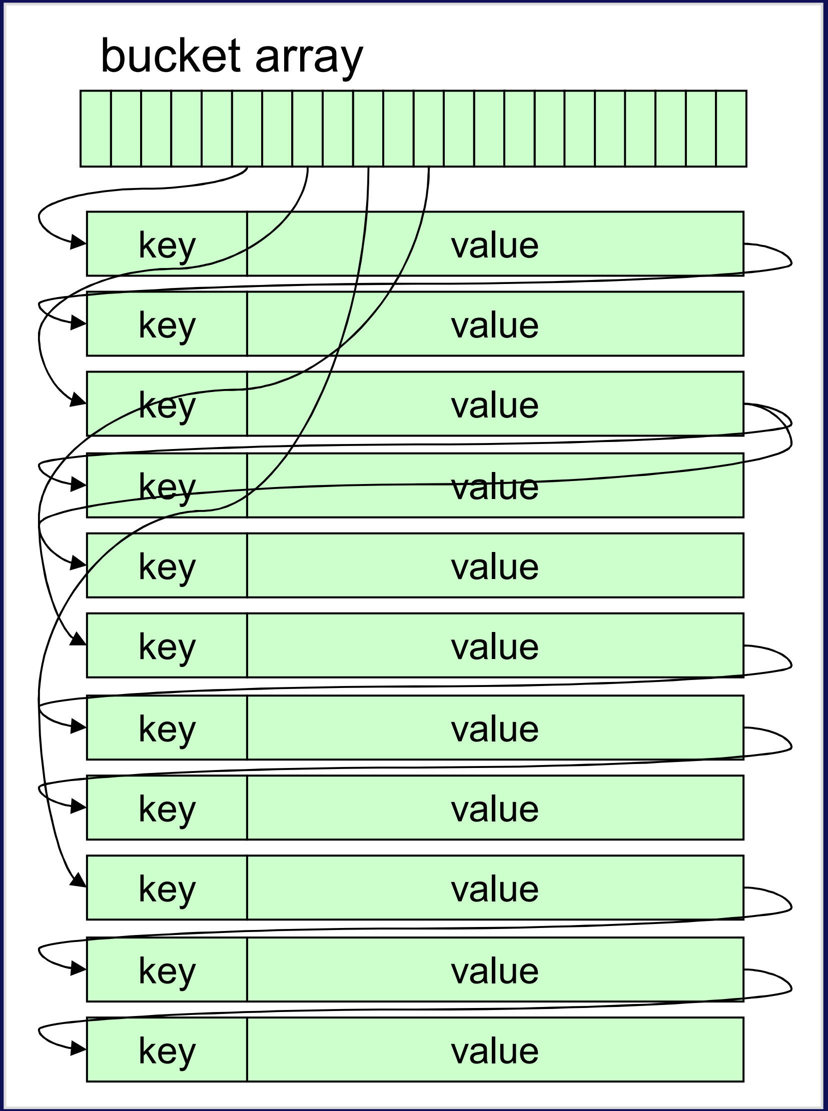
Features

- straightforward implementation
  - key/value database
    - e.g.) DBM, NDBM, GDBM, TDB, CDB, Berkeley DB
  - simple library = process embedded
    - Successor of QDBM, sibling of Tokyo Cabinet
  - C++03 (with TR1) and C++0x portable
    - Linux, FreeBSD, Solaris, Mac OS X
    - Windows
- high performance
  - insert: 1.0 sec/1M records (1,000,000 qps)
  - search: 0.5 sec/1M records (2,000,000 qps)

- high concurrency
  - multi-thread safe
  - read/write locking by records
- high scalability
  - hash and B+tree structure = O(1) and O(log N)
  - no actual limit size of a database file (to 8 exabytes)
- transaction
  - write ahead logging and shadow paging
  - ACID properties
- various APIs
  - on-memory: hash table, binary search tree, LRU list
  - persistent file: hash table, B+ tree
- script language bindings
  - Java, Python, Ruby, Perl, Lua, and so on
  - the "C" binding is also provided

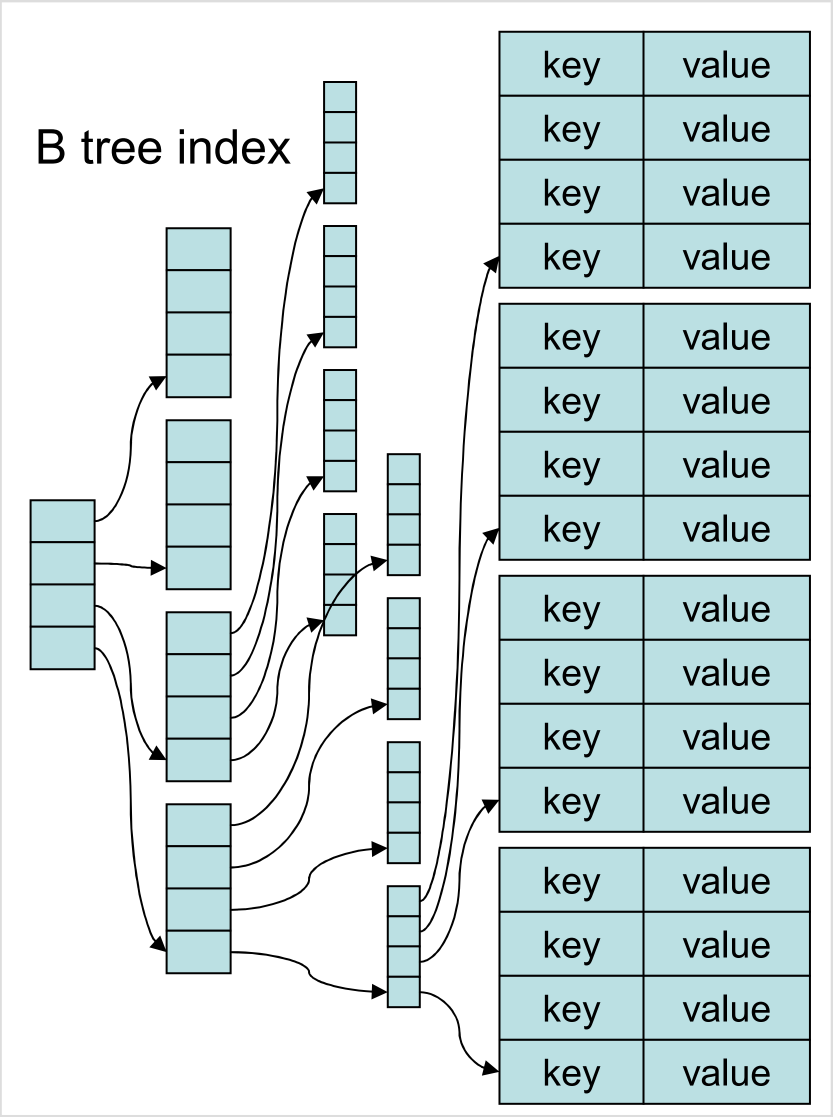
HashDB: File Hash DB

- static hashing
  - O(1) time complexity
  - jilted dynamic hashing for simplicity and performance
- separate chaining
  - binary search tree
  - balances by the second hash
- free block pool
  - best fit allocation
  - dynamic defragmentation
- combines mmap and pwrite/pread
  - saves calling system calls
- compression
  - deflate(gzip)/custom



TreeDB: File B+ Tree DB

- B+ tree
  - O(log N) time complexity
- page caching
  - separated LRU lists
  - mid-point insersion
- stands on hash DB
  - records pages in hash DB
  - succeeds time and space efficiency
- custom comparison function
  - prefix/range matching
- cursor
  - jump/next/prev



On-memory Databases

- ProtoDB: Prototype DB
  - DB wrapper for STL map
  - any data structure compatible std::map are available
  - ProtoHashDB: alias of ProtoDB<std::unordered_map>
  - ProtoTreeDB: alias of ProtoDB<std::map>
- CacheDB: Cache DB
  - hash table with double linked list
  - constant memory usage
  - LRU (least recent used) records are removed
  - snapshot: dump/load current records with a file

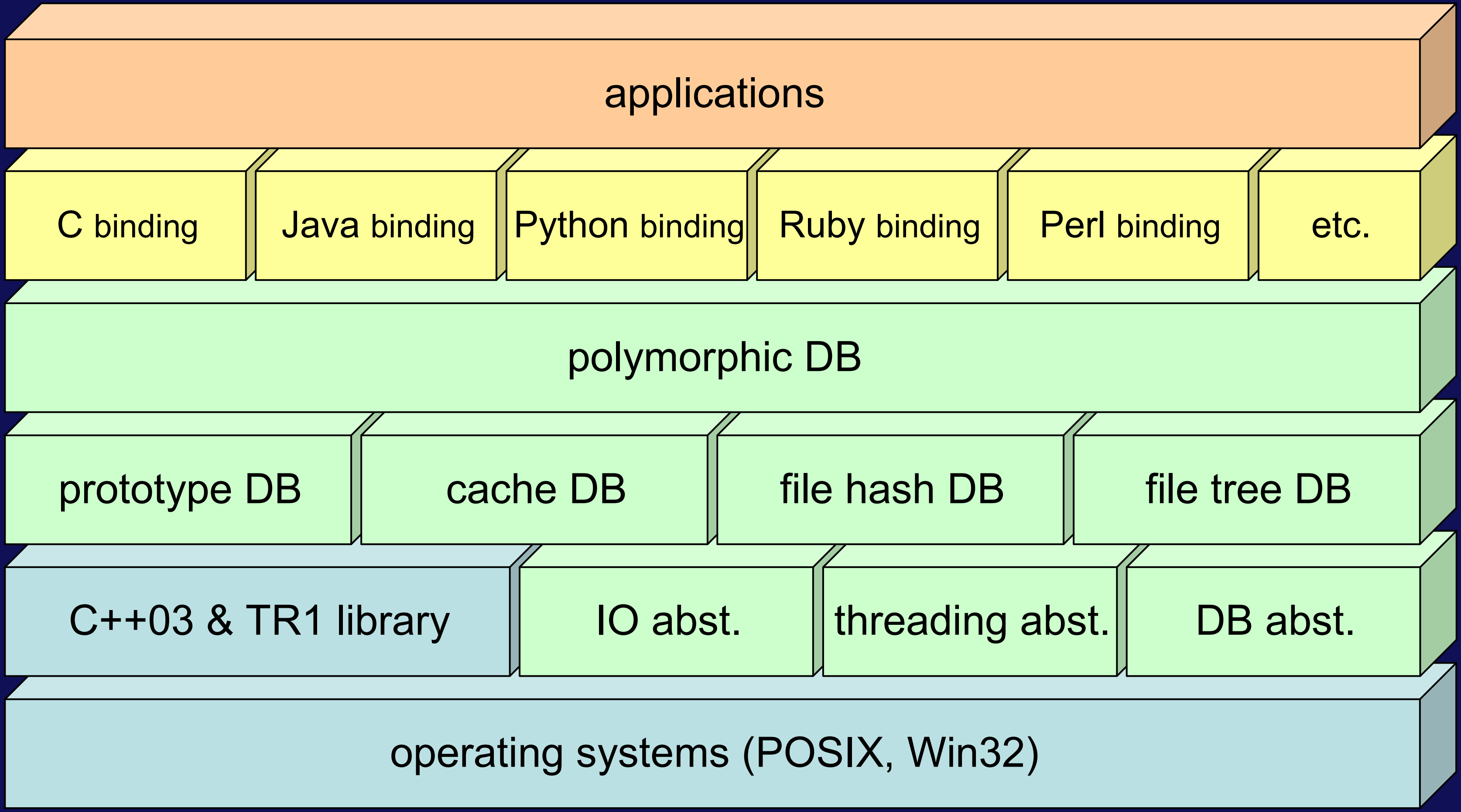
Comparison among DB Types

class	ProtoHashDB	ProtoTreeDB	CacheDB	HashDB	TreeDB
persistence	volatile	volatile	volatile	persistent	persistent
algorithm	hash table	red black tree	hash table	hash table	B+ tree
complexity	O(1)	O(log N)	O(1)	O(1)	O(log N)
sequence	undefined	lexical order	undefined	undefined	custom order
lock unit	whole (rwlock)	whole (rwlock)	record (mutex)	record (rwlock)	page (rwlock)

Class Hierarchy

- DB = interface of record operations
  - FileDB = interface of file operation, mix-in of utilities
    - ProtoHashDB, ProtoTreeDB, HashDB, TreeDB
    - PolyDB
- PolyDB: polymorphic database
  - dynamic binding to four DB types
    - "factory method" and "strategy" patterns
  - the concrete type is determined when opening
    - naming convention
      - ProtoHashDB: "-", ProtoTreeDB: "+", CacheDB: "*"
      - HashDB: "_.kch", TreeDB: "_.kct"

Components



applications

C binding

Java binding

Python binding

Ruby binding

Perl binding

etc.

polymorphic DB

prototype DB

cache DB

file hash DB

file tree DB

C++03 & TR1 library

IO abst.

threading abst.

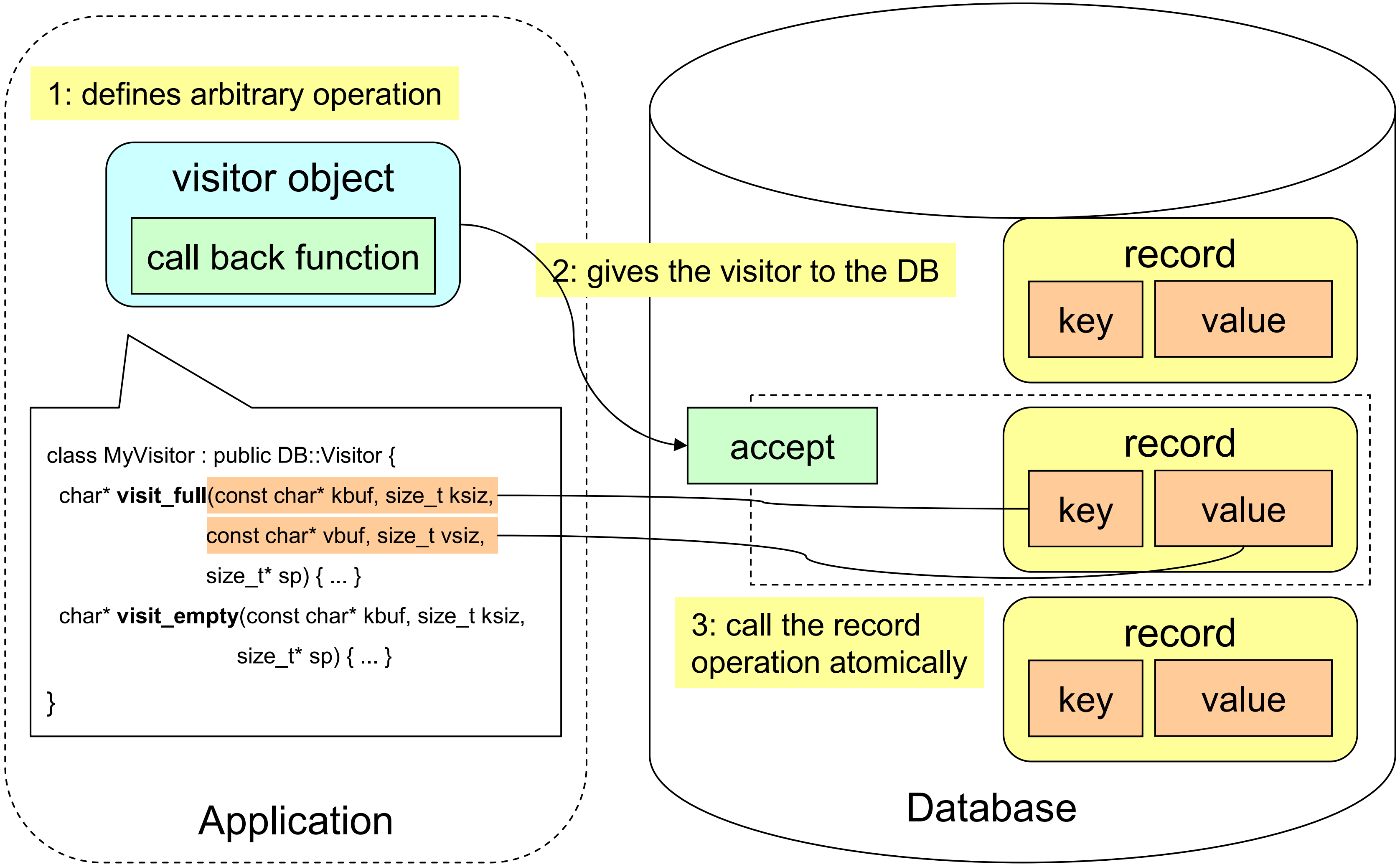
DB abst.

operating systems (POSIX, Win32)

Abstraction of KVS

- what is "Key Value Storage" ?
  - each record consists of one key and one value
  - atomicity is assured for only one record
  - records are stored in persistent storage
- so, what?
  - every operation can be abstracted by "visitor" pattern
  - the database accepts one visitor in a record at the same time
    - lets him read/write the record arbitrary
    - saves the operated value
- flexible and useful interface
  - provides the "DB::accept" method realizing anything
  - "DB::set", "DB::get", "DB::remove", "DB::increment" are built-in as wrappers of the "DB::accept"

Visitor Interface



1: defines arbitrary operation
visitor object
call back function
2: gives the visitor to the DB
accept
record
key
value
record
key
value
record
key
value
3: call the record operation atomically
Application
Database

```
class MyVisitor : public DB::Visitor {
  char* visit_full(const char* kbuf, size_t ksiz,
                   const char* vbuf, size_t vsiz,
                   size_t* sp) { ... }
  char* visit_empty(const char* kbuf, size_t ksiz,
                    size_t* sp) { ... }
}
```

Comparison with Tokyo Cabinet

- Pros
  - space efficiency: smaller size of DB file
    - footprint/record: TC=22B → KC=16B
  - parallelism: higher performance in multi-thread environment
    - uses atomic operations such as CAS
  - portability: non-POSIX platform support
    - supports Win32
  - usability: object-oriented design
    - external cursor, generalization by the visitor pattern
  - robustness: auto transaction and auto recovery
- Cons
  - time efficiency per thread: due to grained lock
  - dependency on modern C++ implementation

Example Code

```
#include <kcpolydb.h>

using namespace std;
using namespace kyotocabinet;

// main routine
int main(int argc, char** argv) {
  // create the database object
  PolyDB db;
  // open the database
  if (!db.open("casket.kch", PolyDB::OWRITER | PolyDB::OCREATE)) {
    cerr << "open error: " << db.error().name() << endl;
  }
  // store records
  if (!db.set("foo", "hop") ||
      !db.set("bar", "step") ||
      !db.set("baz", "jump")) {
    cerr << "set error: " << db.error().name() << endl;
  }
  // retrieve a record
  string* value = db.get("foo");
  if (value) {
    cout << *value << endl;
    delete value;
  } else {
    cerr << "get error: " << db.error().name() << endl;
  }
  // traverse records
  DB::Cursor* cur = db.cursor();
  cur->jump();
  pair<string, string>* rec;
  while ((rec = cur->get_pair(true)) != NULL) {
    cout << rec->first << ":" << rec->second << endl;
    delete rec;
  }
  delete cur;
  // close the database
  if (!db.close()) {
    cerr << "close error: " << db.error().name() << endl;
  }
  return 0;
}
```

```
#include <kcpolydb.h>

using namespace std;
using namespace kyotocabinet;

// main routine
int main(int argc, char** argv) {
  // create the database object
  PolyDB db;
  // open the database
  if (!db.open("casket.kch", PolyDB::OREADER)) {
    cerr << "open error: " << db.error().name() << endl;
  }
  // define the visitor
  class VisitorImpl : public DB::Visitor {
    // call back function for an existing record
    const char* visit_full(const char* kbuf, size_t ksiz,
                           const char* vbuf, size_t vsiz, size_t *sp) {
      cout << string(kbuf, ksiz) << ":" << string(vbuf, vsiz) << endl;
      return NOP;
    }
    // call back function for an empty record space
    const char* visit_empty(const char* kbuf, size_t ksiz, size_t *sp) {
      cerr << string(kbuf, ksiz) << " is missing" << endl;
      return NOP;
    }
  } visitor;
  // retrieve a record with visitor
  if (!db.accept("foo", 3, &visitor, false) ||
      !db.accept("dummy", 5, &visitor, false)) {
    cerr << "accept error: " << db.error().name() << endl;
  }
  // traverse records with visitor
  if (!db.iterate(&visitor, false)) {
    cerr << "iterate error: " << db.error().name() << endl;
  }
  // close the database
  if (!db.close()) {
    cerr << "close error: " << db.error().name() << endl;
  }
  return 0;
}
```

Other Kyoto Series?

- Now, planning.
- Kyoto Tyrant?
  - network service of KC
- Kyoto Dystopia?
  - full-text search engine on KC

maintainability is my paramount concern...

http://1978th.net/

京都 ↖

キャビネット

8 EiB