```
 1: // $Id: listmap.h,v 1.30 2021-12-20 12:56:53-08 - - $
 2:
 3: #ifndef LISTMAP_H
 4: #define LISTMAP_H
 5:
 6: #include "debug.h"
 7: #include "xless.h"
 8: #include "xpair.h"
 9:
10: #define SHOW_LINK(FLAG,PTR) { \
11:            DEBUGF (FLAG, #PTR << "=" << PTR \
12:                    << ": next=" << PTR->next \
13:                    << ", prev=" << PTR->prev); \
14:         }
15:
16: template <typename key_t, typename mapped_t, class less_t=xless<key_t>>
17: class listmap {
18:    public:
19:       using key_type = key_t;
20:       using mapped_type = mapped_t;
21:       using value_type = xpair<const key_type, mapped_type>;
22:    private:
23:       less_t less;
24:       struct node;
25:       struct link {
26:          node* next{};
27:          node* prev{};
28:          link (node* next_, node* prev_): next(next_), prev(prev_){}
29:       };
30:       struct node: link {
31:          value_type value{};
32:          node (node* next_, node* prev_, const value_type& value_):
33:                link (next_, prev_), value(value_){}
34:       };
35:       node* anchor() { return static_cast<node*> (&anchor_); }
36:       link anchor_ {anchor(), anchor()};
37:    public:
38:       class iterator;
39:       listmap(){};
40:       listmap (const listmap&);
41:       listmap& operator= (const listmap&);
42:       ~listmap();
43:       iterator insert (const value_type&);
44:       iterator find (const key_type&);
45:       iterator erase (iterator position);
46:       iterator begin() { return anchor()->next; }
47:       iterator end() { return anchor(); }
48:       bool empty() const { return anchor_.next == &anchor_; }
49:       operator bool() const { return not empty(); }
50: };
51:
```

```
52:
53: template <typename key_t, typename mapped_t, class less_t>
54: class listmap<key_t,mapped_t,less_t>::iterator {
55:    friend class listmap<key_t,mapped_t,less_t>;
56:    private:
57:       listmap<key_t,mapped_t,less_t>::node* where {nullptr};
58:       iterator (node* where_): where(where_){};
59:    public:
60:       iterator() {}
61:       value_type& operator*() {
62:          SHOW_LINK ('b', where);
63:          return where->value;
64:       }
65:       value_type* operator->() { return &(where->value); }
66:       iterator& operator++() { where = where->next; return *this; }
67:       iterator& operator--() { where = where->prev; return *this; }
68:       bool operator== (const iterator& that) const {
69:          return this->where == that.where;
70:       }
71:       bool operator!= (const iterator& that) const {
72:          return this->where != that.where;
73:       }
74:       operator bool() const { return where != nullptr; }
75: };
76:
77: #include "listmap.tcc"
78: #endif
79:
```

```
 1: // $Id: listmap.tcc,v 1.15 2019-10-30 12:44:53-07 - - $
 2:
 3: #include "listmap.h"
 4: #include "debug.h"
 5:
 6: //
 7: //////////////////////////////////////////////////////////////////
 8: // Operations on listmap.
 9: //////////////////////////////////////////////////////////////////
10: //
11:
12: //
13: // listmap::~listmap()
14: //
15: template <typename key_t, typename mapped_t, class less_t>
16: listmap<key_t,mapped_t,less_t>::~listmap() {
17:    DEBUGF ('l', reinterpret_cast<const void*> (this));
18: }
19:
20: //
21: // iterator listmap::insert (const value_type&)
22: //
23: template <typename key_t, typename mapped_t, class less_t>
24: typename listmap<key_t,mapped_t,less_t>::iterator
25: listmap<key_t,mapped_t,less_t>::insert (const value_type& pair) {
26:    DEBUGF ('l', &pair << "->" << pair);
27:    return iterator();
28: }
29:
30: //
31: // listmap::find(const key_type&)
32: //
33: template <typename key_t, typename mapped_t, class less_t>
34: typename listmap<key_t,mapped_t,less_t>::iterator
35: listmap<key_t,mapped_t,less_t>::find (const key_type& that) {
36:    DEBUGF ('l', that);
37:    return iterator();
38: }
39:
40: //
41: // iterator listmap::erase (iterator position)
42: //
43: template <typename key_t, typename mapped_t, class less_t>
44: typename listmap<key_t,mapped_t,less_t>::iterator
45: listmap<key_t,mapped_t,less_t>::erase (iterator position) {
46:    DEBUGF ('l', &*position);
47:    return iterator();
48: }
49:
50:
```

```
 1: // $Id: xless.h,v 1.4 2021-12-20 12:56:53-08 - - $
 2:
 3: #ifndef XLESS_H
 4: #define XLESS_H
 5:
 6: //
 7: // We assume that the type type_t has an operator< function.
 8: //
 9:
10: template <typename Type>
11: struct xless {
12:    bool operator() (const Type& left, const Type& right) const {
13:       return left < right;
14:    }
15: };
16:
17: #endif
18:
```

```
 1: // $Id: xpair.h,v 1.7 2021-12-20 12:56:53-08 - - $
 2:
 3: #ifndef XPAIR_H
 4: #define XPAIR_H
 5:
 6: #include <iostream>
 7:
 8: using namespace std;
 9:
10: //
11: // Class xpair works like pair(c++).
12: //
13: // The implicitly generated members will work, because they just
14: // send messages to the first and second fields, respectively.
15: // Caution:  xpair() does not initialize its fields unless
16: // first_t and second_t do so with their default ctors.
17: //
18:
19: template <typename first_t, typename second_t>
20: struct xpair {
21:    first_t first{};
22:    second_t second{};
23:    xpair() = default;
24:    xpair (const first_t& first_, const second_t& second_):
25:                  first(first_), second(second_) {}
26: };
27:
28: template <typename first_t, typename second_t>
29: ostream& operator<< (ostream& out,
30:                      const xpair<first_t,second_t>& pair) {
31:    out << "{" << pair.first << "," << pair.second << "}";
32:    return out;
33: }
34:
35: #endif
36:
```

```
 1: // $Id: debug.h,v 1.7 2021-12-20 12:56:53-08 - - $
 2:
 3: #ifndef DEBUG_H
 4: #define DEBUG_H
 5:
 6: #include <bitset>
 7: #include <climits>
 8: #include <string>
 9: using namespace std;
10:
11: // debug -
12: //    static class for maintaining global debug flags.
13: // setflags -
14: //    Takes a string argument, and sets a flag for each char in the
15: //    string.  As a special case, '@', sets all flags.
16: // getflag -
17: //    Used by the DEBUGF macro to check to see if a flag has been set.
18: //    Not to be called by user code.
19:
20: class debugflags {
21:    private:
22:       using flagset_ = bitset<UCHAR_MAX + 1>;
23:       static flagset_ flags_;
24:    public:
25:       static void setflags (const string& optflags);
26:       static bool getflag (char flag);
27:       static void where (char flag, const char* file, int line,
28:                          const char* pretty_function);
29: };
30:
```

```
31:
32: // DEBUGF -
33: //    Macro which expands into trace code.  First argument is a
34: //    trace flag char, second argument is output code that can
35: //    be sandwiched between <<.  Beware of operator precedence.
36: //    Example:
37: //       DEBUGF ('u', "foo = " << foo);
38: //    will print two words and a newline if flag 'u' is  on.
39: //    Traces are preceded by filename, line number, and function.
40:
41: #ifdef NDEBUG
42: #define DEBUGF(FLAG,CODE) ;
43: #define DEBUGS(FLAG,STMT) ;
44: #else
45: #define DEBUGF(FLAG,CODE) { \
46:            if (debugflags::getflag (FLAG)) { \
47:               debugflags::where (FLAG, __FILE__, __LINE__, \
48:                                  __PRETTY_FUNCTION__); \
49:               cerr << CODE << endl; \
50:            } \
51:         }
52: #define DEBUGS(FLAG,STMT) { \
53:            if (debugflags::getflag (FLAG)) { \
54:               debugflags::where (FLAG, __FILE__, __LINE__, \
55:                                  __PRETTY_FUNCTION__); \
56:               STMT; \
57:            } \
58:         }
59: #endif
60:
61: #endif
62:
```

```
 1: // $Id: debug.cpp,v 1.4 2021-10-26 22:04:38-07 - - $
 2:
 3: #include <climits>
 4: #include <iostream>
 5: #include <vector>
 6:
 7: using namespace std;
 8:
 9: #include "debug.h"
10: #include "util.h"
11:
12: debugflags::flagset_ debugflags::flags_ {};
13:
14: void debugflags::setflags (const string& initflags) {
15:    for (const unsigned char flag: initflags) {
16:       if (flag == '@') flags_.set();
17:                   else flags_.set (flag, true);
18:    }
19: }
20:
21: // getflag -
22: //    Check to see if a certain flag is on.
23:
24: bool debugflags::getflag (char flag) {
25:    // WARNING: Don't TRACE this function or the stack will blow up.
26:    return flags_.test (static_cast<unsigned char> (flag));
27: }
28:
29: void debugflags::where (char flag, const char* file, int line,
30:                         const char* pretty_function) {
31:    cout << "DEBUG(" << flag << ") "
32:         << file << "[" << line << "] " << endl
33:         << "... " << pretty_function << endl;
34: }
35:
```

```
// $Id: util.h,v 1.10 2021-12-20 12:56:53-08 - - $

//
// util -
//    A utility class to provide various services not conveniently
//    associated with other modules.
//

#ifndef UTIL_H
#define UTIL_H

#include <iostream>
#include <stdexcept>
#include <string>
using namespace std;

//
// sys_info -
//    Keep track of execname and exit status.  Must be initialized
//    as the first thing done inside main.  Main should call:
//       sys_info::set_execname (argv[0]);
//    before anything else.
//

class sys_info {
   private:
      static string execname_;
      static int exit_status_;
      static void execname (const string& argv0);
      friend int main (int, char**);
   public:
      static const string& execname ();
      static void exit_status (int status);
      static int exit_status ();
};

```

```
37:
38: //
39: // complain -
40: //    Used for starting error messages.  Sets the exit status to
41: //    EXIT_FAILURE, writes the program name to cerr, and then
42: //    returns the cerr ostream.  Example:
43: //       complain() << filename << ": some problem" << endl;
44: //
45:
46: ostream& complain();
47:
48: //
49: // syscall_error -
50: //    Complain about a failed system call.  Argument is the name
51: //    of the object causing trouble.  The extern errno must contain
52: //    the reason for the problem.
53: //
54:
55: void syscall_error (const string&);
56:
57: //
58: // string to_string (thing) -
59: //    Convert anything into a string if it has an ostream<< operator.
60: //
61:
62: template <typename item_t>
63: string to_string (const item_t&);
64:
65: //
66: // thing from_string (cons string&) -
67: //    Scan a string for something if it has an istream>> operator.
68: //
69:
70: template <typename item_t>
71: item_t from_string (const string&);
72:
73: //
74: // Put the RCS Id string in the object file.
75: //
76:
77: #include "util.tcc"
78: #endif
79:
```

```
 1: // $Id: util.tcc,v 1.4 2020-02-06 12:33:29-08 - - $
 2:
 3: #include <sstream>
 4: #include <typeinfo>
 5: using namespace std;
 6:
 7: template <typename Type>
 8: string to_string (const Type& that) {
 9:    ostringstream stream;
10:    stream << that;
11:    return stream.str();
12: }
13:
14: template <typename Type>
15: Type from_string (const string& that) {
16:    stringstream stream;
17:    stream << that;
18:    Type result;
19:    if (not (stream >> result and stream.eof())) {
20:       throw domain_error (string (typeid (Type).name())
21:             + " from_string (" + that + ")");
22:    }
23:    return result;
24: }
25:
```

```
 1: // $Id: util.cpp,v 1.18 2020-02-06 12:55:59-08 - - $
 2:
 3: #include <cassert>
 4: #include <cerrno>
 5: #include <cstdlib>
 6: #include <cstring>
 7: #include <ctime>
 8: #include <stdexcept>
 9: #include <string>
10: using namespace std;
11:
12: #include "debug.h"
13: #include "util.h"
14:
15: int sys_info::exit_status_ = EXIT_SUCCESS;
16: string sys_info::execname_; // Must be initialized from main().
17:
18: void sys_info::execname (const string& argv0) {
19:    assert (execname_ == "");
20:    int slashpos = argv0.find_last_of ('/') + 1;
21:    execname_ = argv0.substr (slashpos);
22:    cout << boolalpha;
23:    cerr << boolalpha;
24:    DEBUGF ('u', "execname_ = " << execname_);
25: }
26:
27: const string& sys_info::execname () {
28:    assert (execname_ != "");
29:    return execname_;
30: }
31:
32: void sys_info::exit_status (int status) {
33:    assert (execname_ != "");
34:    exit_status_ = status;
35: }
36:
37: int sys_info::exit_status () {
38:    assert (execname_ != "");
39:    return exit_status_;
40: }
41:
42: ostream& complain() {
43:    sys_info::exit_status (EXIT_FAILURE);
44:    cerr << sys_info::execname () << ": ";
45:    return cerr;
46: }
47:
48: void syscall_error (const string& object) {
49:    complain() << object << ": " << strerror (errno) << endl;
50: }
51:
```

```
// $Id: main.cpp,v 1.13 2021-02-01 18:58:18-08 - - $

#include <cstdlib>
#include <exception>
#include <iostream>
#include <string>
#include <unistd.h>

using namespace std;

#include "listmap.h"
#include "xpair.h"
#include "util.h"

using str_str_map = listmap<string,string>;
using str_str_pair = str_str_map::value_type;

void scan_options (int argc, char** argv) {
   opterr = 0;
   for (;;) {
      int option = getopt (argc, argv, "@:");
      if (option == EOF) break;
      switch (option) {
         case '@':
            debugflags::setflags (optarg);
            break;
         default:
            complain() << "-" << char (optopt) << ": invalid option"
                       << endl;
            break;
      }
   }
}

int main (int argc, char** argv) {
   sys_info::execname (argv[0]);
   scan_options (argc, argv);

   str_str_map test;
   cout << test << endl;
   for (char** argp = &argv[optind]; argp != &argv[argc]; ++argp) {
      str_str_pair pair (*argp, to_string<int> (argp - argv));
      cout << "Before insert: " << pair << endl;
      test.insert (pair);
   }

   cout << test.empty() << endl;
   for (str_str_map::iterator itor = test.begin();
        itor != test.end(); ++itor) {
      cout << "During iteration: " << *itor << endl;
   }

   str_str_map::iterator itor = test.begin();
   test.erase (itor);

   cout << "EXIT_SUCCESS" << endl;
   return EXIT_SUCCESS;
}
```

```
59:
```

```
# $Id: Makefile,v 1.27 2021-10-26 22:04:38-07 - - $

MKFILE      = Makefile
DEPFILE     = ${MKFILE}.dep
NOINCL      = ci clean spotless check lint
NEEDINCL    = ${filter ${NOINCL}, ${MAKECMDGOALS}}
GMAKE       = ${MAKE} --no-print-directory

GPPWARN     = -Wall -Wextra -Wpedantic -Wshadow -Wold-style-cast
GPPOPTS     = ${GPPWARN} -fdiagnostics-color=never
COMPILECPP  = g++ -std=gnu++2a -g -O0 ${GPPOPTS}
MAKEDEPCPP  = g++ -std=gnu++2a -MM ${GPPOPTS}
UTILBIN     = /afs/cats.ucsc.edu/courses/cse111-wm/bin

MODULES     = listmap xless xpair debug util main
CPPSOURCE   = ${wildcard ${MODULES:=.cpp}}
OBJECTS     = ${CPPSOURCE:.cpp=.o}
SOURCELIST  = ${foreach MOD, ${MODULES}, ${MOD}.h ${MOD}.tcc ${MOD}.cpp}
ALLSOURCE   = ${wildcard ${SOURCELIST}}
EXECBIN     = keyvalue
OTHERS      = ${MKFILE} ${DEPFILE}
ALLSOURCES  = ${ALLSOURCE} ${OTHERS}
LISTING     = Listing.ps

all : ${EXECBIN}

${EXECBIN} : ${OBJECTS}
        ${COMPILECPP} -o $@ ${OBJECTS}

%.o : %.cpp
        ${COMPILECPP} -c $<

lint : ${CPPSOURCE}
        ${UTILBIN}/cpplint.py.perl ${CPPSOURCE}

check : ${ALLSOURCES}
        ${UTILBIN}/checksource ${ALLSOURCES}

ci : ${ALLSOURCES}
        ${UTILBIN}/cid -is ${ALLSOURCES}

lis : ${ALLSOURCES}
        mkpspdf ${LISTING} ${ALLSOURCES}

clean :
        - rm ${OBJECTS} ${DEPFILE} core

spotless : clean
        - rm ${EXECBIN} ${LISTING} ${LISTING:.ps=.pdf}

dep : ${ALLCPPSRC}
        @ echo "# ${DEPFILE} created `LC_TIME=C date`" >${DEPFILE}
        ${MAKEDEPCPP} ${CPPSOURCE} >>${DEPFILE}

${DEPFILE} :
        @ touch ${DEPFILE}
        ${GMAKE} dep

```

```
59: again :
60:         ${GMAKE} spotless dep ci all lis
61:
62: ifeq (${NEEDINCL}, )
63: include ${DEPFILE}
64: endif
65:
```

```
1: # Makefile.dep created Tue Feb  1 20:56:38 PST 2022
2: debug.o: debug.cpp debug.h util.h util.tcc
3: util.o: util.cpp debug.h util.h util.tcc
4: main.o: main.cpp listmap.h debug.h xless.h xpair.h listmap.tcc util.h \
5:  util.tcc
```