```c
/*
* New_Alarm_Cond.c

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* This is an enhancement to the alarm_cond.c program, which
* used only a mutex and condition variables to synchronize acces
* to a list of alarms. This versions does the job by only using
* semaphores
*/
#include <pthread.h>
#include <time.h>
#include "errors.h"
#include <semaphore.h>

/*
* The "alarm" structure now contains the time_t (time since the
* Epoch, in seconds) for each alarm, so that they can be
* sorted. Storing the requested number of seconds would not be
* enough, since the "alarm thread" cannot tell how long it has
* been on the list.
*/
typedef struct alarm_tag {
  struct alarm_tag    *link;
  int                 seconds;
  time_t              time;   /* seconds from EPOCH */
  char                message[128];

  /******* new additions to the alarm_tag structure ********/
  int               type; //identifies the message type ( type >= 1 )
  int               prev_type; // previous message type
  int               is_new; // 1 == "new" and 0 == "old/not new"
  int               number; /* Message Number */
  int               request_type; // TypeA == 1 TypeB == 2 TypeC == 3
  int               expo; // signifies that the type change was confirmed
  /********************end new additions***************/
} alarm_t;

/*
*
* Thread structure used to keep a linked list of thread id's which will be
* organized by their message type.
*
* This is a replacement of the sparce matrix used in the previous project
* "New_Alarm_Mutex.c". This is a lot more efficient as it does not Allocate
* an unneccesary amount of space. we do loose the O(1) acces time though.
*/
typedef struct thread_tag { // NEW STRUCT
  struct thread_tag     *link;
  pthread_t             thread_id;
  int                   type;
  int                   number;
```

```
58
59 } thread_t;
60
61 sem_t rw_sem;
62 int read_count = 0; // number o readers using the list
63 int writing = 0; //flag to notify that there is a writer writing to the list
64 int ready = 0; // flag to notify readers that a writer is about to write
65
66 alarm_t *alarm_list = NULL;
67 time_t current_alarm = 0;
68 thread_t *thread_list = NULL;  // List of Thread id's
69
70 const int TYPE_A = 1; // Constants to specify alarm request type
71 const int TYPE_B = 2;
72 const int TYPE_C = 3;
73
74 int insert_flag; //1 if a new alarm has been inserted. set to 0 after processing
75
76 int debug_flag;
77
78 /*************************HELPER CODE*************************/////////////
79 /*
80 * prints out contents of the thread list as well as the contents of the alarm
81 * list for debugging
82 */
83 void display_lists(){
84   thread_t **last, *next;
85   alarm_t **alast, *anext;
86
87   last = &thread_list;
88   next = *last;
89
90   alast = &alarm_list;
91   anext = *alast;
92
93   printf ("\n[Thread List: ");
94   for (next = thread_list; next != NULL; next = next->link)
95     printf ("{message type = %d thread_id = <%lu>} ",next->type,next->thread_id);
96   printf ("]\n");
97
98   printf ("[Alarm List: ");
99     for (anext = alarm_list; anext != NULL; anext = anext->link)
100      printf (" {Request Type = %d Alarm # = %d message type = %d} ",
101              anext->request_type, anext->number, anext->type);
102  printf ("]\n");
103 }
104
105
106 /*
107 * checks if an alarm's type has changed
108 *
109 * returns 1 if so and 0 otherwise
110 */
111 int check_prev(alarm_t *a){
112
113   if(a->type != a->prev_type)
114     return 1;
```

```
115
116   return 0;
117 }
118
119
120 /*
121 * Check the alarm list to see if a Type A alarm of this type number exists.
122 *
123 * return 1 if so and 0 otherwise.
124 *
125 */
126 int check_type_a_exists(int type){
127   int     status;
128   alarm_t *next, **last;
129
130   last = &alarm_list;
131   next = *last;
132   while (next != NULL) {
133     if(next->type == type && next->request_type == TYPE_A){
134
135       return 1;
136     }
137
138     last = &next->link;
139     next = next->link;
140   }
141
142   return 0;
143 }
144
145 /*
146 * Check the alarm list to see if a Type A alarm of this message number exists.
147 *
148 * return 1 if so and 0 otherwise.
149 *
150 */
151 int check_number_a_exists(int num){
152   int     status;
153   alarm_t *next, **last;
154
155   last = &alarm_list;
156   next = *last;
157   while (next != NULL) {
158     if(next->number == num && next->request_type == TYPE_A){
159       return 1;
160     }
161
162     last = &next->link;
163     next = next->link;
164   }
165
166   return 0;
167 }
168
169 /*
170 * Check the alarm list to see if an alarm with this type already exists.
171 * Takes the message type and request type as parameters
```

```
172 *
173 * return 1 if so and 0 otherwise.
174 */
175 int check_dup(int type, int req){
176   int     status;
177   alarm_t *next, **last;
178
179   last = &alarm_list;
180   next = *last;
181   while (next != NULL) {
182     if(next->type == type && next->request_type == req){
183       return 1; // it exists already
184     }
185
186     last = &next->link;
187     next = next->link;
188   }
189   return 0; // It doesn't exist.
190 }
191
192 /*
193 * Check the alarm list to see if an alarm with this number already exists.
194 * Takes the message number and request type as parameters
195 *
196 * return 1 if so and 0 otherwise.
197 *
198 */
199 int check_dup_2(int num, int req){
200   int     status;
201   alarm_t *next, **last;
202
203   last = &alarm_list;
204   next = *last;
205   while (next != NULL) {
206     if(next->number == num && next->request_type == req){
207
208       return 1; // it exists already
209     }
210
211     last = &next->link;
212     next = next->link;
213   }
214   return 0; // It doesn't exist.
215 }
216
217 /*
218 * Removes a Type A alarm of the specified message number from the alarm list
219 *
220 * Returns the message type of the alarm that was just removed from alarm list
221 *
222 * Requires Mutex for alarm list to prevent writing while readers are reading
223 * Mutex is needed because this method removes from (writes to) the alarm list
224 */
225 int remove_alarm(int number){
226   alarm_t **last, *next;
227   int val = 0;
228
```

```
229   /*
230   * LOCKING PROTOCOL:
231   *
232   * This routine requires that the caller have locked the
233   * alarm_mutex!
234   */
235   last = &alarm_list;
236   next = *last;
237
238   /*
239   * If list is empty, return 0;
240   */
241   if (next == NULL)
242     return val;
243
244   while (next != NULL){
245
246     /*
247     * if we find the alarm within the list, delete it.
248     */
249     if (next->number == number && next->request_type == TYPE_A){
250       val = next->type;
251       *last = next->link;
252       free(next);
253       break; // remove the thread the Alarm.
254     }
255
256     last = &next->link;
257     next = next->link;
258   }
259
260   return val;
261
262 }
263
264 /*
265 * Removes a type B alarm request responsible for type A alarms with the
266 * specified type
267 *
268 * Requires Mutex for alarm list to prevent writing while readers are reading
269 * Mutex is needed because this method removes from (writes to) the alarm list
270 */
271 void remove_alarm_B(int type){
272   alarm_t **last, *next;
273   /*
274   * LOCKING PROTOCOL:
275   *
276   * This routine requires that the caller have locked the
277   * alarm_mutex!
278   */
279   last = &alarm_list;
280   next = *last;
281
282   while (next != NULL){
283     /*
284     * if we find the alarm within the list, delete it.
285     */
```

```
286     if (next->request_type == TYPE_B && next->type == type){
287       *last = next->link;
288       free(next);
289       break; // remove the thread the Alarm.
290     }
291
292     last = &next->link;
293     next = next->link;
294   }// End while
295 }
296
297
298 /*
299 * Removes a type C alarm request responsible for cancelling alarms with the
300 * specified alarm number type
301 *
302 * Requires Mutex for alarm list to prevent writing while readers are reading
303 * Mutex is needed because this method removes from (writes to) the alarm list
304 */
305 void remove_alarm_C(int number){
306   alarm_t **last, *next;
307   /*
308   * LOCKING PROTOCOL:
309   *
310   * This routine requires that the caller have locked the
311   * alarm_mutex!
312   */
313   last = &alarm_list;
314   next = *last;
315
316   while (next != NULL){
317     /*
318     * if we find the alarm within the list, delete it.
319     */
320     if (next->request_type == TYPE_C && next->number == number){
321       *last = next->link;
322       free(next);
323       break; // remove the thread the Alarm.
324     }
325
326     last = &next->link;
327     next = next->link;
328   }// End while
329 }
330
331 /*
332 * Insert alarm entry on list, in order of message number.
333 *
334 * Requires Mutex for alarm list to prevent writing while readers are reading
335 * Mutex is needed because this method removes from (writes to) the alarm list
336 */
337 void alarm_insert (alarm_t *alarm){
338   int status;
339   alarm_t **last, *next;
340
341   /*
342   * LOCKING PROTOCOL:
```

```
343   *
344   * This routine requires that the caller have locked the
345   * alarm_mutex!
346   */
347   last = &alarm_list;
348   next = *last;
349   while (next != NULL) {
350
351     /*
352     * Replace existing alarm or insert the new alarm arranged by message number.
353     *
354     * If the alarm is a type B request, it will be inserted in the front as it
355     * has a Message Number of 0.
356     * If the alarm is a type C request, it will be inserted along Type A's.
357     */
358     if (next->number == alarm->number && alarm->request_type == TYPE_A){//A.3.2.2
359
360       // swap the nodes (Replacement)
361       alarm->link = next->link;
362       alarm->prev_type = next->type;
363       *last = alarm;
364       free(next);
365       printf("Type A Replacement Alarm Request With Message Number (%d) "
366       "Received at <%d>: <A>\n", alarm->number, (int)time(NULL));
367       break; // Add the Alarm.
368
369     }else if (next->number > alarm->number){
370
371       alarm->link = next;
372       *last = alarm;
373       break; // Add the Alarm.
374
375      }
376
377     last = &next->link;
378     next = next->link;
379   }
380   /*
381   * If we reached the end of the list, insert the new alarm
382   * there.  ("next" is NULL, and "last" points to the link
383   * field of the last item, or to the list header.)
384   */
385   if (next == NULL) {
386     *last = alarm;
387     alarm->link = NULL;
388   }
389 }
390
391 ///THREAD STUFF
392
393 /*
394 * insert thread id into the thread list in order of Message Type
395 *
396 */
397 void insert_thread(thread_t *thread){
398
399   thread_t **last, *next;
```

```
400
401   last = &thread_list;
402   next = *last;
403   while (next != NULL) {
404
405     /*
406     * insert the thread id into the thread list
407     */
408     if (next->type > thread->type){
409
410       thread->link = next;
411       *last = thread;
412       break; // Add the Alarm.
413
414      }
415
416     last = &next->link;
417     next = next->link;
418   }
419   /*
420   * If we reached the end of the list, insert the new thread
421   * there.  ("next" is NULL, and "last" points to the link
422   * field of the last item, or to the list header.)
423   */
424   if (next == NULL) {
425     *last = thread;
426     thread->link = NULL;
427   }
428 }
429
430 /*
431 * ittereate through the thread list and terminate threads
432 * of MessageType(Type)
433 * also removes it from the thread list
434 *
435 * Note that every thread is allowed to complete its routine before terminatied
436 * this is to avoid the mutex being locked and not having a way to unlock it
437 *
438 */
439 void terminate_thread(int type){
440   thread_t **last, *next;
441   last = &thread_list;
442   next = *last;
443
444   while (next != NULL){
445
446     /*
447     * if we find the thread within the list, delete it.
448     */
449     if (next->type == type){
450
451       int success = pthread_cancel(next->thread_id); //terminate that thread
452       if(success != 0) // checks if the thread was successfuly terminated
453         err_abort (success, "thread was not canceled");
454
455       *last = next->link;
456       free(next);
```

```
457       break; // remove the thread.
458
459     }
460     last = &next->link;
461     next = next->link;
462   }// End while
463 }
464
465 /*
466 *
467 * Check the thread list to see if there are any useless threads in the list.
468 * A thread is considered useless if there are no Type A alarms of its message
469 * type available to be printed
470 *
471 * terminate the thread if such thread exists and return 1. If no such thread
472 * exists, return 0
473 *
474 */
475 int check_useless_thread(){
476   thread_t **last, *next;
477
478   last = &thread_list;
479   next = *last;
480
481   /*
482   * loop throught the thread list and check the alarm list for Type A alarms
483   * that have the same message type as the thread. if at least 1 exists, return
484   * 0.
485   */
486   while(next != NULL){
487
488     if(check_type_a_exists(next->type) == 0){
489       terminate_thread(next->type);
490       return 1;
491     }
492     next = next->link;
493   }
494
495   return 0;
496 }
497
498 /*
499 *
500 * used to delay a mesage 'sec' seconds before printing
501 *
502 */
503 void delay(int sec){
504   int now = time(NULL);
505   int till = now + sec;
506
507   while(till > now)
508     now = time(NULL);
509 }
510
511 /*
512 * When debug mode is activated, prints out the contents of the alarm list as
513 * well as the thread list. Also prints out the values for the semaphore
```

```
514 * variables (during the time debud is called) used for mutual exclusion.
515 *
516 */
517 void debug(){
518
519   if (debug_flag){
520     display_lists();
521     printf("Ready = %d read_count = %d writing = %d\n\n", ready, read_count, writing );
522   }
523
524 }
525 /**************************END HELPER CODE**************************/////////
526
527
528 /* READER
529 *
530 * TYPE B CREATED THREAD (periodic display thread).
531 * responsible for periodically looking up a Type A alarm request with a
532 * Message Type in the alarm list, then printing, every Time seconds.
533 *
534 * A3.4
535 */
536 void *periodic_display_thread(void *arg){
537   alarm_t *alarm = alarm_list;
538   int status, flag;
539
540   int *arg_pointer = arg;
541   int type = *arg_pointer; // parameter passed by the create thread call
542
543   //data
544   char r_message[128]; int r_type, r_sec, r_num, r_req_type;
545   /////
546
547   /*
548   * Loop forever, processing Type A alarms of specified message type.
549   * The alarm thread will be disintegrated when the process exits.
550   */
551
552   while (1){
553
554     while(ready > 0){
555       // wrtiter is ready to trite so don't do anything
556     }
557
558     pthread_setcancelstate(PTHREAD_CANCEL_DISABLE, NULL); //disable cancellation
559     while (alarm_list == NULL){
560       ///// ACHTUNG! /////
561       pthread_setcancelstate(PTHREAD_CANCEL_ENABLE, NULL); //enable cancellation
562       pthread_testcancel();
563     }
564
565     /////
566     if (flag == 1){
567       alarm = alarm_list; // go back to the beginning
568       flag = 0;
569     }
570     if (alarm->link == NULL){
```

```
571       flag = 1; // go back to the beginning of the list
572     }
573     /////
574 
575     read_count++;
576     /* read all the importnat data */
577     r_type = alarm->type;
578     r_num = alarm->number;
579     r_sec = alarm->seconds;
580     r_req_type = alarm->request_type;
581     strcpy(r_message, alarm->message);
582     ////////////////////////////////
583     if(r_type != type && r_req_type == TYPE_A){ //A.3.4.2
584       /*
585       * check if its type has changed. if its type has changed from a different
586       * one, notify the user that an alarm with the specified type which
587       * previously had a different type has been assigned.
588       */
589       if(check_prev(alarm) == 1 && alarm->prev_type == type){
590         if(alarm->expo == 0){ // check if alarm change has been acknowledged
591           printf("Alarm With Message Type (%d) Replaced at <%d>: "
592           "<Type A>\n", r_type, (int)time(NULL)); // A.3.4.2
593           alarm->expo = 1; // alarm exposed (chanhe acknowledged)
594         }
595       }
596     }
597     alarm = alarm->link; // go to the next node on the list
598     read_count--;
599 
600     /* used to avoid potential deadlock from thread termination
601     */
602     pthread_setcancelstate(PTHREAD_CANCEL_ENABLE, NULL); //enable cancellation
603     pthread_testcancel(); // set a cancellation point
604 
605     if(r_type == type && r_req_type == TYPE_A){ //A.3.4.1
606       delay(r_sec);
607       // PRINT MESSAGE // A.3.4.1
608       printf("Alarm With Message Type (%d) and Message Number"
609       " (%d) Displayed at <%d>: <Type A> : ",
610       r_type, r_num, (int)time(NULL) );
611       printf ("\"%s\"\n", r_message);
612     }
613   }// End While(1)
614 }
615 
616 /*WRITER
617 *
618 * The alarm thread's start routine.
619 *
620 * An initial thread which is responsible for looping through the
621 * alarm list and checking the status of each type A alarm, as well as performing
622 * type B or C requests as they are inserted.
623 *
624 * A3.3
625 */
626 void *alarm_thread (void *arg){
627 
```

```
628  alarm_t **last, *next;
629  int status;
630
631  /*
632  * Loop forever, processing commands. The alarm thread will
633  * be disintegrated when the process exits.
634  */
635
636  while (1){
637
638    /*
639    * If a new alarm hasnt been added, wait until a new alarm is
640    * added
641    */
642
643     while (insert_flag == 0) {
644       //busy wait
645     }
646
647    /*
648    * when a new alarm has been inserted, loop through the alarm list and find
649    * and process the alarm
650    */
651    last = &alarm_list;
652    next = *last;
653
654    while(next != NULL){
655
656      /*
657      * upon finding a new type A alarm, checks if there exists a useless
658      * periodic display thread and terminates it if such thread exists.
659      */
660      if(next->request_type == TYPE_A){ // A.3.3.1
661        if(next->is_new == 1){
662          next->is_new = 0; // alarm is no longer new
663
664          status = check_useless_thread(); // remove possible useless threads
665          if (status == 1){ // then remove it from the alarm list
666            ////////////////
667            ready++; // the writer is ready to use the alarm list
668            while(read_count > 0 || writing > 0){
669              // busy waits for readers to be done
670            }
671            status = sem_wait(&rw_sem);
672            if(status != 0)
673              err_abort(status, "rw_sem wait");
674            writing++; // writer has control of the data structure
675            /* critical section */
676
677            remove_alarm_B(next->prev_type); // remove it from the list
678            debug();
679
680            writing--;
681            status = sem_post(&rw_sem);
682            if(status != 0)
683              err_abort(status, "rw_sem post");
684            ready--;
```

```
685           ////////////////
686         }else{
687           debug();
688         }
689         break;
690       }
691     }// END TYPE A ***************************///////
692
693     /*
694     * upon finding a new type B alarm, creates a periodic display thread
695     * responsible for printing messages its specified type
696     */
697     else if(next->request_type == TYPE_B){ // A.3.3.2
698       if(next->is_new == 1){
699
700         next->is_new = 0; // alarm is no longer new
701         thread_t *thrd;
702         pthread_t thread;
703
704
705         thrd = (thread_t*)malloc (sizeof (thread_t)); //allocate thread struct
706         if (thrd == NULL)
707         errno_abort ("Allocate Thread");
708
709         /* create a thread for periodically printing messages
710         *  pass message type as an argument
711         */
712         status = pthread_create(&thread, NULL, periodic_display_thread,
713         &next->type);
714         if (status != 0)
715           err_abort (status, "Create alarm thread"); // A.3.3.2 (a)
716         thrd->type = next->type; // set the attributes for the thread struct
717         thrd->thread_id = thread;
718
719         insert_thread(thrd);
720
721         printf("Type B Alarm Request Processed at <%d>: New Periodic Dis"
722         "play Thread With Message Type (%d) Created.\n", (int)(time(NULL)),
723         next->type ); // A.3.3.2 (b)
724         debug();
725         break;
726       }
727     }// END TYPE B ***************************///////
728
729     /*
730     * upon finding a new type C alarm, removes the alarm of the message
731     * number specified by the Type C alarm from the alarm list.
732     *
733     * if there are no more alarm requests in the alarm list the same type as
734     * the one that was just removed, terminate the periodic display thread
735     * responsible for displaying those messages.
736     *
737     * This is the only part of the  alarm thread that writes to the alarm list
738     */
739     else if(next->request_type == TYPE_C){ //A.3.3.3
740       int val;
741       if(next->is_new == 1){
```

```
742           next->is_new == 0; // alarm is no longer new
743
744
745           ready++; // the writer is ready to use the alarm list
746           while(read_count > 0 || writing > 0){
747             // busy waits for readers to be done
748           }
749           status = sem_wait(&rw_sem);
750           if(status != 0)
751             err_abort(status, "rw_sem wait");
752           writing++; // writer has control of the data structure
753
754
755           val = remove_alarm(next->number); // A.3.3.3 (a)
756           if(val != 0){ // A.3.3.3 (c)
757
758             remove_alarm_C(next->number);// remove alarm from the alarm list
759             printf("Type C Alarm Request Processed at <%d>: Alarm Request"
760             " With Message Number (%d) Removed\n", (int)(time(NULL)),
761             next->number);
762           }
763
764           if(check_type_a_exists(val) == 0){ // A.3.3.3 (b)
765
766             terminate_thread(val); // terminate the thread
767             remove_alarm_B(val); // remove the B alarm from alarm list
768             remove_alarm_C(next->number);// remove alarm from the alarm list
769
770             printf("No More Alarm Requests With Message Type (%d):"
771             " Periodic Display Thread For Message Type (%d)"
772             " Terminated.\n", val, val); // A.3.3.3 (d)
773
774           }debug();
775
776           writing--;
777           status = sem_post(&rw_sem);
778           if(status != 0)
779             err_abort(status, "rw_sem post");
780           ready--;
781         }
782         break;
783       }// END TYPE C ***************************///////
784       next = next->link; //go to the next node
785     } // End list loop
786     insert_flag = 0; // finished looping and processd new alarm
787   }
788 }
789
790 /*WRITER
791 * Parses inputs as specified in assaignment 3 outline
792 *
793 * Creates 3 different alarm requests (Type A - C) and inserts them into the
794 * alarm list. THe alarm thread then processes these alarm requests as they already
795 * inserted
796 */
797 int main (int argc, char *argv[]){
798   int status;
```

```
799   char line[128];
800   char deb[8];
801   alarm_t *alarm;
802   thread_t *thrd;
803   pthread_t thread;
804
805   status = sem_init(&rw_sem, 0, 1); // initialize reader writer Semaphore
806   if(status != 0)
807     err_abort(status, "Create READ-WRITE Semaphore");
808
809   /*
810   * Create the initial thread responsible for looping through the alarm list
811   * and performing operations depening on the request type
812   *
813   * leaving the argument "NULL" would also imply that the initial thread
814   */
815   status = pthread_create (&thread, NULL, alarm_thread, NULL);
816   if (status != 0) err_abort (status, "Create alarm thread");
817
818   while (1) {
819     printf ("alarm> ");
820     if (fgets (line, sizeof (line), stdin) == NULL) exit (0);
821     if (strlen (line) <= 1) continue;
822     alarm = (alarm_t*)malloc (sizeof (alarm_t));
823     if (alarm == NULL) errno_abort ("Allocate alarm");
824
825     /*
826     * Parse input line into seconds (%d) and a message
827     * (%64[^\n]), consisting of up to 64 characters
828     * separated from the seconds by whitespace.
829     *
830     * Checks what type of alarm / message is being entered.
831     *
832     */
833     /*************************TYPE A************************/
834     if (sscanf (line, "%d Message(%d, %d) %128[^\n]",
835     &alarm->seconds, &alarm->type, &alarm->number, alarm->message) == 4 &&
836     alarm->seconds > 0 && alarm->number > 0 && alarm->type > 0){ // A.3.2.1
837
838       alarm->time = time (NULL) + alarm->seconds;
839       alarm->request_type = TYPE_A;
840       alarm->is_new = 1;
841       alarm->prev_type = alarm->type;
842
843       ready++; // the writer is ready to use the alarm list
844       while(read_count > 0 || writing > 0){
845         // wait for readers or writers to finish
846       }
847       status = sem_wait(&rw_sem);
848       if(status != 0)
849         err_abort(status, "rw_sem wait");
850       writing++; // writer has control of the data structure
851       /*
852       * Insert the new alarm into the list of alarms, CRITICAL SECTION
853       */
854       alarm_insert (alarm);
855       printf("Type A Alarm Request With Message Number <%d> Received at"
```

```
856       " time <%d>: <Type A>\n", alarm->number, (int)time(NULL));
857
858       insert_flag = 1; // a new alarm has been inserted
859
860       writing--;
861       status = sem_post(&rw_sem);
862       if(status != 0)
863         err_abort(status, "rw_sem post");
864       ready--;
865
866     }
867     /*********************END TYPE A************************/
868     /************************TYPE B************************/
869     else if (sscanf(line,"Create_Thread: MessageType(%d)",&alarm->type) == 1
870     && alarm->type > 0){ // A.3.2.3 - A.3.2.5
871
872       int exists = check_type_a_exists(alarm->type);
873       int dup = check_dup(alarm->type, TYPE_B);
874       /*
875       * Creates a Type B alarm that is then inserted into the alarm list.
876       * Does not allow for duplicate type B alarms.
877       * Only creates one if there exists a type A alarm of type B's
878       * Message Type.
879       */
880
881       if(exists == 0){ // A.3.2.3
882
883         printf("Type B Alarm Request Error: No Alarm Request With Message Type"
884         "(%d)!\n", alarm->type);
885         free(alarm); // deallocate alarm that isn't used
886
887       }else if(dup == 1){ // A.3.2.4
888         // May need to fix as there is confusion between "Number" and "Type"
889         printf("Error: More Than One Type B Alarm Request With"
890           " Message Type (%d)!\n", alarm->type );
891         free(alarm); // deallocate alarm that isn't used
892
893       }else if(exists == 1 && dup == 0){ //A.3.2.5
894
895         alarm->request_type = TYPE_B;
896         alarm->is_new = 1;
897
898         ready++; //
899         while(read_count > 0 || writing > 0){
900           // busy wait
901         }
902         status = sem_wait(&rw_sem);
903         if(status != 0)
904           err_abort(status, "rw_sem wait");
905         writing++; // writer has control of the data structure
906
907         /*
908         * Insert the new alarm into the list of alarms
909         * Insert the new thread into the list of threads
910         */
911         alarm_insert (alarm);
912         printf("Type B Create Thread Alarm Request With Message Type (%d)"
```

```
913         " Inserted Into Alarm List at <%d>!\n", alarm->type, (int)time(NULL));
914         insert_flag = 1; // a new alarm has been inserted
915 
916         writing--;
917         status = sem_post(&rw_sem);
918         if(status != 0)
919           err_abort(status, "rw_sem post");
920         ready--;
921       }
922     }
923     /*********************END TYPE B************************/
924     /************************TYPE C************************/
925     else if (sscanf (line, "Cancel: Message(%d)", &alarm->number) == 1 &&
926     alarm->number > 0 ){ //
927 
928       int exists = check_number_a_exists(alarm->number);
929       int dup2 = check_dup_2(alarm->number, TYPE_C);
930 
931       /*
932       * Creates a Type C alarm that is then inserted into the alarm list.
933       * Does not allow for duplicate type alarms.
934       * Only creates one if there exists a type A alarm of type C's Message
935       * Type.
936       */
937 
938       if (exists == 0){ // A.3.2.6
939 
940         printf("Error: No Alarm Request With Message"
941           " Number (%d) to Cancel!\n", alarm->number );
942         free(alarm);
943 
944       }else if (dup2 == 1){ // A.3.2.7
945 
946         printf("Error: More Than One Request to Cancel Alarm Request With"
947           " Message Number (%d)!\n", alarm->number);
948         free(alarm);
949 
950       }else if (exists == 1 && dup2 == 0 ){ // A.3.2.8
951 
952         alarm->request_type = TYPE_C;
953         alarm->is_new = 1;
954 
955 
956         ready++;
957         while(read_count > 0 || writing > 0){
958           // busy wait
959         }
960         status = sem_wait(&rw_sem);
961         if(status != 0)
962           err_abort(status, "rw_sem wait");
963         writing++; // writer has control of the data structure
964 
965         /*
966         * Insert the new alarm into the list of alarms.
967         */
968         alarm_insert (alarm);
969         printf("Type C Cancel Alarm Request With Message Number (%d)"
```

```
970           " Inserted Into Alarm List at <%d>: <Type C>\n", alarm->number,
971               (int)time(NULL));
972
973         insert_flag = 1; // a new alarm has been inserted
974
975         writing--;
976         status = sem_post(&rw_sem);
977         if(status != 0)
978           err_abort(status, "rw_sem post");
979         ready--;
980       }
981     }
982     /*********************END TYPE C************************/
983     else if (sscanf(line,"%s", deb) && strcmp("debug",deb) == 0){ // debugging
984       if (debug_flag == 0){
985         printf("**DEBUG MODE ENGAGED**\n");
986         debug_flag = 1;
987       }else{
988         printf("**DEBUG MODE DISENGAGED**\n");
989         debug_flag = 0;
990       }
991
992     }
993     else{
994       fprintf (stderr, "Bad command\n");
995       free (alarm);
996     }
997   }// end while
998 }
999
```