Laboratorio di Sistemi Operativi
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AMIKaya Phase 1 Project Specifications

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- **AMIKaya is:**
  - a complete Operating System project specification developed by Enrico Cataldi and based on Kaya and AMIKE
  - designed as a *microkernel* system, to be developed in a number of *phases*; can be implemented using the uMPS simulator
  - Phase 1 is the first software layer of AMIKaya (below it there are only bare hardware and ROM microcode)
  - Phase 1 requires the development of Thread Queue and Message Queue Managers

- **Why to develop Queue Managers?**
  - because threads, messages and their queues are the basic data structures managed by any microkernel
  - to provide the required ADTs (*Abstract Data Types*) to AMIKaya's phase2
  - to gain experience in software development and debugging by using the uMPS simulator

- **Queue Manager goals:**
  - Queue managers = a collection of *modules* that will be used in Phase 2
  - Should implement the following features:
    - allocation and de-allocation of single ThreadBLK and MessageBLK descriptors
    - maintenance of ThreadBLK queues
    - maintenance of ThreadBLK trees
    - maintenance of MessageBLK queues

Queue Manager features:

- Allocation of ThreadBLK and MessageBLK descriptors:
  - No OS = no heap = no dynamic memory allocation
  - How to allocate these descriptors?
  - *static* allocation: define
    - an array of `MAXTHREADS` ThreadBLKs
    - an array of `MAXMESSAGES` MessageBLKs
  - and use a *free list* (that is, a list of free elements) for each: `tcbFree` and `msgFree`
  - `MAXTHREADS` and `MAXMESSAGES` will be provided with p1test
  - `MAXMESSAGES` could be redefined in Phase 2 to handle the number of messages generated by p2test

Thread Control Block definition (ThreadBLK):

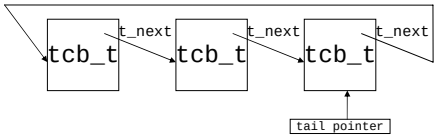
```
/* thread control block */
 typedef struct tcb_t {
        /* thread queue fields */
        struct tcb_t    *t_next, /* pointer to next entry */

        /* thread tree fields */
                        *t_parent, /* pointer to parent */
                        *t_sibling, /* pointer to next sibling */
                        *t_child; /* pointer to 1st child */

        /* thread's message queue */
        struct msg_t *inbox;

        struct state_t proc_state;    /* processor state */

        /* Other fields will be added during phase2 development */
 } tcb_t;
```


Allocation-related functions:

- **`void initTcbs(void);`**
  Initialize the tcbFree list.
  This method will be called only once during data structure initialization
- **`void freeTcb(tcb_t *t);`**
  Insert the element pointed to by t onto the tcbFree list
- **`tcb_t * allocTcb(void);`**
  Return NULL if the tcbFree list is empty, otherwise remove an element from the tcbFree list, provide initial values for *all* of the ThreadBLK's fields (i.e. NULL and/or 0) and then return a pointer to the removed element; ThreadBLKs get reused, so it is important that no previous value remains in a ThreadBLK when it gets reallocated

ThreadBLK Queue features:

- Circular, single-linked, tail pointed; using `t_next`
- Efficiency may be improved introducing double-linked queues (and `t_prev`)
- Implementation (and documentation) of a more sophisticated data structure gives a bonus

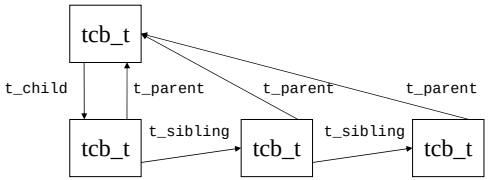


Maintenance of ThreadBLK Queues:

```
tcb_t * mkEmptyThreadQ(void);
        Used to initialize a variable to be tail pointer to a thread queue;
        returns a pointer to the tail of an empty thread queue, i.e. NULL
int     emptyThreadQ(tcb_t *tp);
        Returns TRUE if the queue whose tail is pointed to by tp is empty,
        FALSE otherwise.
void    insertThread(tcb_t **tp, tcb_t *t_ptr);
        Insert the ThreadBLK pointed to by t_ptr into the thread queue whose
        tail-pointer is pointed to by tp; note the double indirection through
        tp to allow for the possible updating of the tail pointer as well
tcb_t * removeThread(tcb_t **tp);
        Remove the first (i.e. head) element from the thread queue whose
        tail-pointer is pointed to by tp. Return NULL if the thread queue was
        initially empty; otherwise return the pointer to the removed element.
        Update the process queue's tail pointer if necessary
tcb_t * outThread(tcb_t **tp, tcb_t *t_ptr);
        Remove the ThreadBLK pointed to by t_ptr from the queue whose tail-pointer
        is pointed to by tp. Update the queue's tail pointer if necessary.
        If the desired entry is not in the queue (an error condition), return NULL;
        otherwise, return t_ptr. Note: t_ptr can point to any element of the queue
tcb_t * headThread(tcb_t *tp);
        Return a pointer to the first ThreadBLK from the queue whose tail is
        pointed to by tp. Do not remove the ThreadBLK from the queue.
        Return NULL if the queue is empty
```


Maintenance of ThreadBLK trees:

- Implemented using `t_parent`, `t_child`, `t_sibling`
- Efficiency may be improved introducing double-linked queues at sibling level (and `t_prev_sibling`)
- Implementation (and documentation) of a more sophisticated data structure gives a bonus



Maintenance of ThreadBLK trees:

```
int   emptyChild(tcb_t *t);
      Return TRUE if the ThreadBLK pointed to by t has no children,
      FALSE otherwise.

void  insertChild(tcb_t *prnt, tcb_t *t);
      Make the ThreadBLK pointed to by t a child of the ThreadBLK pointed to by
      prnt. In other words: insert t in the thread tree as a child of prnt

tcb_t * removeChild(tcb_t *t);
      Make the first child of the ThreadBLK pointed by t no longer a child of t.
      Return NULL if there are no t's children, otherwise a pointer to the
      removed ThreadBLK first child. In other words: if t has children, remove
      the first one from the tree and return a pointer to it,
      otherwise return NULL

tcb_t * outChild(tcb_t *t);
      Make the ThreadBLK pointed to by t no longer the child of its parent. If the
      ThreadBLK pointed to by t has no parent, return NULL, otherwise return t.
      The element pointed by t need not be the first child of its parent.
      In other words: look in the tree for the ThreadBLK pointed by t; if t has
      no parent, return NULL; if it does have a parent, remove t from the tree
      and return t
```


Message definition (MessageBLK):

```
/* message block */
typedef struct msg_t{
        struct msg_t *m_next; /* pointer to next entry */

        struct tcb_t *m_sender; /* thread that sent this message */
        unsigned int message; /* the payload of the message */

} msg_t;
```

Allocation-related functions:

- **void initMsgs(void);**
  Initialize the msgFree list.
  This method will be called only once during data structure initialization
- **void freeMsg(msg_t *m);**
  Insert the element pointed to by m onto the msgFree list
- **msg_t *allocMsg(void);**
  Return NULL if the msgFree list is empty, otherwise remove an element from the msgFree list, provide initial values for *all* of the MessageBLK's fields (i.e. NULL and/or 0) and then return a pointer to the removed element; MessageBLKs get reused, so it is important that no previous value remains in a MessageBLK when it gets reallocated

MessageBLK Queue features:

- Circular, single-linked, tail pointed; using `m_next`
- Efficiency may be improved introducing double-linked queues (and `m_prev`)
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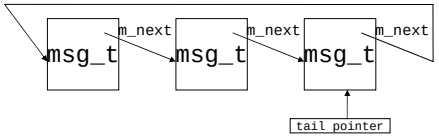

Maintenance of MessageBLK Queues:

msg_t * mkEmptyMessageQ(void);
Used to initialize a variable to be tail pointer to a message queue; returns a pointer to the tail of an empty message queue, i.e. NULL

int emptyMessageQ(msg_t *mp);
Returns TRUE if the queue whose tail is pointed to by mp is empty, FALSE otherwise

void insertMessage(msg_t **mp, msg_t *m_ptr);
Insert the MessageBLK pointed to by m_ptr at the ***end*** of the queue whose tail-pointer is pointed to by mp; note the double indirection through mp to allow for the possible updating of the tail pointer as well

void pushMessage(msg_t **mp, msg_t *m_ptr);
Insert the MessageBLK pointed to by m_ptr at the ***head*** of the queue whose tail-pointer is pointed to by mp; note the double indirection through mp to allow for the possible updating of the tail pointer as well

msg_t * popMessage(msg_t **mp, tcb_t *t_ptr);
Remove the first element (starting by the head) from the message queue accessed via mp whose sender is t_ptr. If t_ptr is NULL, return the first message in the queue. Return NULL if the message queue was empty or if no message from t_ptr was found; otherwise return the pointer to the removed message. Update the message queue's tail pointer if necessary

msg_t * headMessage(msg_t *mp);
Return a pointer to the first MessageBLK from the queue whose tail is pointed to by mp. Do not remove the MessageBLK from the queue.
Return NULL if the queue is empty

Some observations on Phase 1:

- Specifications may not look clear:
  - you have to think there is a bigger picture
  - focus on module structure and features
- Writing the code:
  - start writing stubs; build one step at a time and keep it simple
  - check for error conditions (plan for the unforeseen)
  - analyze and understand `p1test.c`
  - look at the examples provided with uMPS
- remember `#define HIDDEN static` for module data structures