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ภาคผนวก

program listing

```
/*-----------------------------
 *      LAP 1.0
 *-----------------------------*/
#include   <syntax.h>            /* Syntax and constant definition */
/*
 *   Machine name
 */
#define        IBMPC              1
/* #define     UNIX               0 */
/*---------------------*
 *  Software constant  *
 *---------------------*/
#define     MAXTIME               1024     /* Max simulation period  */
#define     IDENLEN               6        /* Identifier length      */
#define     CMDLEN                4        /* User command len       */
/*-------------------------------------------*
    Define of some data type used in program
 *-------------------------------------------*/
typedef     char                  NAMESTR[IDENLEN+1];
#define     LOGICSTATE            unsigned char
#define     LOW                   0
#define     HIGH                  1
#define     UNKNOWN               2      /* Unknown  state */
#define     ZSTATE                3      /* High impedance ,donot
                                            change to any value*/
/* Status return from evaluation function */
#define  BUS_CONTENSION       0x80
#define  SPIKE_DETECT         0x40
#define  SEQN_NO_TRIG         0x20
#define  EVAL_NORMAL          0x00
/*---------------------*
    Data Structure
*---------------------*/
#define     MAXIPIN      8                /* Max  I/O pin of model */
#define     MAXOPIN      2                /* Max  OUTPUT IS 2      */
#define     MAXREFOUT    1000             /* Gnd and Vcc maximum FANOUT */
/* Type definition of data used */
typedef  struct  lmodel          LOGICMODEL;
typedef  struct  lnode           LOGICNODE;
typedef  struct  lgate           LOGICELEMENT;
typedef  struct  lsource         LOGICSOURCE;
/*-----------------*
    LOGIC MODEL
 *-----------------*/

/*
    Definition gate Major type
    SEQN  -  standard sequential model
    COMB  -  standard combination model
    FLPF  -  build in flip-flop model
    BUS   -  Bus interface model
*/
enum  main_model{ SEQN,COMB,FLPF,BUS};
/* Define model Minor type */
enum sub_model{AND,OR,INV,NAND,NOR,XOR,BUFF,TFF,DFF,JKFF,DRIVER};

struct  lmodel {
                NAMESTR name;            /* Model  name                */
                enum sub_model   smodel; /* Submodel type              */
```

```
                enum main_model  mmodel; /* Major model type            */
                BYTE clkpin;             /* Pin number of clock for FF  */
                int  inum,onum;          /* Number of I/O pin           */
                int  td;                 /* Transport delay             */
                LOGICSTATE *op[MAXOPIN]; /* Pointer to True Table       */
                LOGICSTATE *state;       /* Pointer to next state table */
                LOGICMODEL *next;
                  } ;
/*-------------*
    LOGIC NODE
 *-------------*/
#define     MAXFANIN              20
#define     MAXFANOUT             20
/* Type of logic node */
#define     INTERN        1     /* Internal node      */
#define     XTERN         2     /* External node      */

struct lnode{
                NAMESTR name;
                BYTE type;               /* Node type             */
                BYTE onum;               /* Output count          */
                BYTE inum;               /* Input count           */
                BYTE simcount;           /* Flag used to detect spike */
                LOGICSTATE  state;       /* logic state of node   */
                LOGICELEMENT  **in,**out;  /* pointer to fin-fout table */
                LOGICSTATE *outstate;      /* pointer to output table   */
                LOGICNODE  *next;
          } ;

/*-----------------*
   LOGIC ELEMENT
 *-----------------*/
    struct lgate {
                NAMESTR name;
                BYTE type;           /* Type of element */
                BYTE onum;           /* Output count    */
                BYTE inum;           /* Input count     */
                LOGICMODEL *model;   /* Model of this element */
                LOGICSTATE ps;       /* Present state for SEQ Element */
                LOGICSTATE cks;      /* Present state of clock pin    */
                int td;              /* Gate delay                    */
                LOGICNODE *in[MAXIPIN],*out[MAXOPIN];
                LOGICELEMENT  *next;
             } ;
/*---------------*
  LOGIC SOURCE
 *---------------*/
/*    Type of logic source      */
#define     LSRC              1   /* USER DEFINE WAVE FORM */
#define     CLKSRC            2   /* CLOCK INPUT           */
#define     MAXSBREAK             20      /* Max Logic source break point  */
     struct lsource {
                NAMESTR name;
                int  stype;          /* Type of logic source  */
                int  index;          /* INDEX COUNT OF SOURCE */
                int  tc;             /* TIME COUNT            */
                int  pnum;           /* PERIOD OF THIS SOURCE */
                LOGICNODE *outnode;  /* NODE THAT THIS SOURCE DRIVE  */
                LOGICSTATE state[MAXSBREAK];  /*  STATE DATA OF SOURCE */
                int  time[MAXSBREAK];  /* time that source change */
                LOGICSOURCE *next;

           } ;
```

```
/*-------------------------------------------------------------
        COMMAND STRUCTURE FOR MODULE COMMUNICATION
      Communication between each module in program use
      command package.When teminate.each module will send
      back  return status.
 *-------------------------------------------------------------*/

/*    Command sending to DISPLAY MODULE module   */
#define     MAX_DISPLAY_NODE      15 /* Maximum node that can display
                                        simultaneously. */
#define     MAXDPSTEP             500    /* Maximum display step        */
#define     MAXDPSCALE            99     /* Maximum display zoom factor */
#define     MAXGRIDSTEP           200    /* Maximum grid width          */
#define     SETUP                 1
#define     TABLE                 2
#define     TIMING                3
#define     NODESEL               4
#define     INITDP                5
/* Type of display device */
typedef     struct {
                BYTE   cmd;       /* operation perform          */
                int    nodisp;    /* Number of node to display */
                int    timestart; /* Time display index         */
                int    rtime;     /* Real time start            */
                BYTE   scale;     /* Scale factor               */
                BYTE   gridstep;  /* Grid step to display       */
                BYTE   waittime;  /* Waiting time for display   */
                LOGICSTATE *simdata[MAX_DISPLAY_NODE];
                char       *nodename[MAX_DISPLAY_NODE];
                } CMD_DISPLAY;

/* Command sending to simulation module */
#define     SIM_SETUP             1
#define     SIM_NEW               2
#define     SIM_CONT              3
typedef     struct {
                int timelen;        /* Time length of simulation */
                BYTE  cmd;          /* operation perform         */
              }  CMD_SIM;
```

```
/*
 *  MODULE:    LAPDATA
 *  AUTHOR:    P.UTHAYOPAS
 *  DATE:
 *
 *      This module contain routine that handle linklist
 *  of circuit data.
 */
typedef  struct listnode  LIST;
struct listnode {
                 void  *first;    /* first element in linklist  */
                 void  *last;     /* last element in link list  */
                 int   num;       /* number of element in li nk list */
                };

/* Some of macro for link list function */
#define  HEAD(listptr)          listptr->first
#define  TAIL(listptr)          listptr->last
#define  LENGTH(listptr)        listptr->num
#define  LOOPLIST(p,listptr)    for(p=listptr->first; p != NULL ;p=p->next)

/* Some of important external variable */
extern  LOGICNODE       *vccptr,*gndptr; /* Pointer to Ref. node */
extern  LIST            *elmhead ;
extern  LIST            *nodehead;
extern  LIST            *srchead ;

/* Type and argument lint for all module */
#ifdef IBMPC
extern void initdata(void);
extern void makerefnode();
extern LOGICELEMENT *getgateptr(char *name);
extern LOGICELEMENT *makenewgate(char *name);
extern LOGICNODE    *getnodeptr(char *name);
extern LOGICNODE    *makenewnode(char *name);
extern LOGICSOURCE  *getsrcptr( char *name);
extern LOGICELEMENT *oldgate(char *name);
extern LOGICSOURCE  *oldsrc(char *name);
extern LOGICNODE    *oldnode(char *name);
extern int          addelm(LOGICELEMENT *p);
extern int          addnode(LOGICNODE *p);
extern void         setnode(char *nodename,char *st);
#else
   #ifdef UNIX
extern void initdata();
extern void makerefnode();
extern LOGICELEMENT *getgateptr();
extern LOGICELEMENT *makenewgate();
extern LOGICNODE    *getnodeptr();
extern LOGICNODE    *makenewnode();
extern LOGICSOURCE  *getsrcptr();
extern LOGICELEMENT *oldgate();
extern LOGICSOURCE  *oldsrc();
extern LOGICNODE    *oldnode();
extern int          addelm();
extern int          addnode();
extern void         setnode();
  #endif
#endif
```

```
/*
 *  MODULE: LAPEDIT
 *  AUTHOR: P.Uthayopas
 *  DATE:
 *
 *       This module get user circuit script from file
 *  and add to data structure
 */

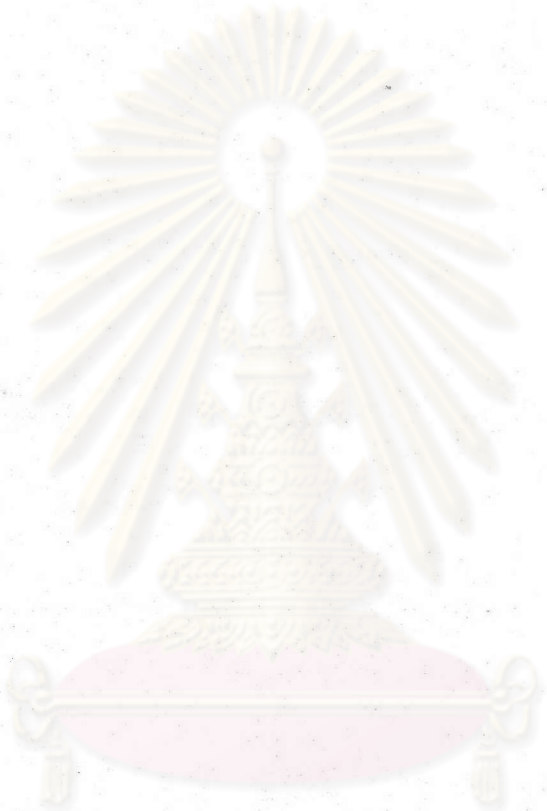
/* FILE FUNCTION COMMAND CODE */
#define   READ       1
#define   WRITE      2
/* COMMAND STRUCTURE FOR FILE HANDLING */
typedef   struct filecmd  CMDFILE;
struct filecmd {
                char *fname;
               };
#ifdef  IBMPC
extern  void  lapfile(int cmd,CMDFILE *data);
extern  void  edititmain(int argc,char *argv[]);
extern  int   fetchstr(char *st);
#else
#ifdef UNIX
extern  void  lapfile();
extern  void  edititmain();
extern  int   fetchstr();
#endif UNIX
#endif IBMPC
```

```
/* LAPUTIL.H */
/*  Key name for getkey function */
#define BS              8
#define FORMFEED        12
#define CR              13
#define ESC             27
#define HOMEKEY         327
#define ENDKEY          335
#define UPKEY           328
#define DOWNKEY         336
#define PGUPKEY         329
#define PGDNKEY         337
#define LEFTKEY         331
#define INSKEY          338
#define RIGHTKEY        333
#define DELKEY          339
#define CTRLLEFTKEY     371
#define CTRLRIGHTKEY    372
#define F1 315
#define F2 316
#define F3 317
#define F4 318
#define F5 319
#define F6 320
#define F7 321
#define F8 322
#define F9 323
#define F10 324
/*
 *  Define error for laperr
 */
#define  SYNTAXERR              01
#define  INVALIDCMD             02
#define  INVALIDMDL             03
#define  MEMFAULT               04

/* COMMAND CODE TABLE FORMAT */
typedef struct cmdtable {
                 char str[9];    /* Command string */
                 int  code;      /* Command code   */
               } CMDTABLE;

extern int   getkey(void);
extern int   getint(void);
extern void  prmlist(int argc,char *argv[]);
extern int   findcode(char *cmd,CMDTABLE  *cmdtab,int length);
extern char  *getcmdln(char *prompt,char *buff);
extern int   strargv(char *ln,char *argv[]);
extern char  *strtrunc(char *st1,char *st2,int n);
extern char  logictoc(LOGICSTATE s);
extern LOGICSTATE tologic(char c);
/* System interface function */
extern int   dir(char *fname);
extern unsigned long diskfree(int drv);
extern unsigned long memavail(void);
extern void  delfile(char *fname);
extern void  typefile(char *fname);
extern void  copyfile(char *source,char *dest);
```

```
/*-----------
   LAPEVAL.H
 *-----------*/
/*  Function  prototype  */
extern LOGICMODEL *getmodelptr(char *);
extern int listmodel(void);
extern int findlogic(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin);
extern void  add_usr_model(LOGICMODEL *model);
extern void  free_usr_model(void);
extern LOGICMODEL *dupmodel(LOGICMODEL *model);
```



```
/*----------------*
    LAPMACRO.H
 *----------------*/
/* Data type used */
typedef  struct  macro    MACRO;
typedef  struct  ingate   MACROGATE;
typedef  struct  msym     MACROSYM;
struct   msym {
                 NAMESTR  str;
                 LOGICNODE *node;
              };
struct ingate {
               NAMESTR   name;
               LOGICMODEL *model;
               int td;
               int inum,onum;
               MACROSYM   *ipin[MAXIPIN];
               MACROSYM   *opin[MAXOPIN];
               struct ingate *next;
              };

struct macro {
              NAMESTR name;                    /* Macro name */
              MACROGATE *gfirst,*glast;  /* Pointer to macro gate link */
              MACROSYM  *xsym,*isym;     /* Pointer to symbol table    */
              int elmnum;        /* Macro gate element count      */
              int inodenum;      /* Internal node count           */
              int xnodenum;      /* External node count           */
              int expand;        /* Macro expansion count         */
              struct  macro *next;
             };

/* Function */
extern void     expandmacro(int argc,char *argv[],MACRO *m);
extern void     editmacro(int margc,char *margv[]);
extern void     listmacro(void);
extern void     freemacro(void);
extern MACRO    *getmacroptr(char *st);
```

```
/*
 *     MODULE:  main
 *     AUTHOR:  P.Uthayopas  B815754
 *     DATE:
 *              This is main module of LAP 1.0 a logic simulation
 *     program on IBM PC/XT.
 */
#include   <stdio.h>
#include   <signal.h>
#include   "lap.h"
#include   "lapcmd.h"
#include   "laputil.h"
#include   "lapedit.h"

#define  MAXARGUMENT            20     /* Maximum command line argument */

/*
 *   IMPORT FUNCTION
 */
#ifdef   IBMPC
IMPORT   void  simulator(CMD_SIM *cmdptr); /* From lapsim.c  */
IMPORT   void  dspmodule(CMD_DISPLAY *cmdptr);     /* From lapdisp   */
IMPORT   void  creat_tq();
#endif
/*
 *  Intern' used function of this module
 */
#ifdef   IBMPC
LOCAL    void  savemain(int argc,char *argv[]);
LOCAL    void  loadmain(int argc,char *argv[]);
LOCAL    void  simmain();
LOCAL    void  displaymain(int argc,char *argv[]);
LOCAL    void  helpmain(void);
LOCAL    void  initdpmodule(void);
#else
#if      UNIX
LOCAL    void  savemain();
LOCAL    void  loadmain();
LOCAL    void  simmain();
LOCAL    void  displaymain();
LOCAL    void  helpmain();
LOCAL    void  initdpmodule();
#endif
#endif
/*
 *   Title : print title message on screen
 */
LOCAL void title()
{
printf("MicroLAP 1.0 : Microcomputer Logic Analysis Program\n\n");
  puts("Developed By : Putchong Uthayopas,B815754");
  puts("               Department of Electrical Engineering");
  puts("               Faculty of Engineering");
  puts("               Chulalongkorn University");
printf("               September ,1988\n\n");
}
/*
 *   LAP HELP MODULE
 *   help file is lap.hlp
 */
```

```
PUBLIC void helpmain()
{
LOCAL char *hlp="LAP.HLP";   /* Help file name */
LOCAL char  linebuff[150];
   FILE *hf;
   int lc;

   if ((hf=fopen(hlp,"r"))==NULL) then
    {  puts("Help file LAP.HLP not found in current directory"); }
    else
     {
       for(lc=0; ! feof(hf); )
        {
          linebuff[0]=NULL;
          fgets(linebuff,150,hf);
          printf("%s",linebuff);
          lc=( lc < 20 ? ++lc : 0);
          if (lc==0) getch();
        }
        fclose(hf);
     }
   printf("\n");
}

/*
 *   File handling interface module
 */

/*
 *       savemain
 *    This function call file saving function
 */
 LOCAL void savemain(argc,argv)
 int argc;
 char *argv[];
 {
    static CMDFILE  buff,*p=&buff;
    char name[20];

    if (argc !=2 ) then
       {
          printf("SAVE <Filename>\n");
          return;
       }
    strcat(argv[1],".LAP");
    p->fname=argv[1];
    lapfile(WRITE,p);
 }

 LOCAL void loadmain(argc,argv)
 int argc;
 char *argv[];
 {
    static CMDFILE  buff,*p=&buff;
    char name[20];

    if (argc !=2 ) then
       {
          printf("LOAD <Filename>\n");
          return;
```

```
        }
    strcat(argv[1],".LAP");
    p->fname=argv[1];
    lapfile(READ,p);
    printf("\n");
}
/*
 *  Simulation module interface
 */
void  simmain(argc,argv)
int argc;
char *argv[];
{
    /* Command for simulator module */
    static CMD_SIM  simbuff,*simcmd=&simbuff;
    static CMDTABLE simcmdtab[]={
                            {"CONT",1},{"STAR",2},{"SET",3}
                             };
    static int  simcmdlen = sizeof(simcmdtab)/sizeof(CMDTABLE);
    char buff[10];
    int  code;

     if (argc >3) { puts("SYNTAX ERROR!"); return; }
     if (argc==1)
        { simcmd->cmd=SIM_NEW;
          simulator(simcmd);
          return; }
     strtrunc(buff,argv[1],CMDLEN); /* Truncate string  */
     code=findcode(buff,simcmdtab,simcmdlen);
     switch(code)
     {
        case 1 :  simcmd->cmd=SIM_CONT;          break;
        case 2 :  simcmd->cmd=SIM_NEW;           break;
        case 3 :  simcmd->cmd=SIM_SETUP;
                  simcmd->timelen=MAXTIME;          break;
        default :   puts("SYNTAX ERROR!");       return;
     }
     simulator(simcmd);
}
/*
 *   Display module interface
 */

/*
 * Share command buffer for display module
 */
LOCAL CMD_DISPLAY disptag;
LOCAL CMD_DISPLAY *dispcmd = &disptag;

LOCAL void initdpmodule()
{
       dispcmd->cmd=INITDP;
       dspmodule(dispcmd);
}

LOCAL void displaymain(argc,argv)
int argc;
char *argv[];
{
    static CMDTABLE dspcmd[]={
```

```
                                {"SET",1},
                                {"TABLE",2},
                                {"SIGNAL",3},
                                {"NODE",4}
                            };
    static int dspcmdlen = sizeof(dspcmd)/sizeof(CMDTABLE);
    static char buff[IDENLEN+2];
    int code;

    dispcmd->waittime=0;
    if (argc==1) then
      {
        dispcmd->cmd=TIMING;
        dspmodule(dispcmd);
        return;
       }
    strtrunc(buff,argv[1],IDENLEN); /* Truncate string  */
    code=findcode(buff,dspcmd,dspcmdlen);
    switch(code)
    {
       case 1   :  dispcmd->cmd=SETUP;
                   break;
       case 2   :  dispcmd->cmd=TABLE;
                   break;
       case 3   :  dispcmd->cmd=TIMING;
                   dispcmd->waittime=atoi(argv[2]);
                   break;
       case 4   :  dispcmd->cmd=NODESEL;
                   break;
    }
    dspmodule(dispcmd);
} /* end of Displaymain */

/*
 *   SETUP PARAMETER MAIN
 */

LOCAL void setupmain(argc,argv)
int argc;
char *argv[];
{

   static CMDTABLE setcmd[]={
            {"DEVICE",1},{"DEV",1} ,{"NODE",2}
                            };
   static int   setcmdlen = sizeof(setcmd)/sizeof(CMDTABLE);

   static char buff[IDENLEN+2];
   int code;

   if (argc==1) { puts("SET <DEVICE,NODE,SIM>"); return; }
   strtrunc(buff,argv[1],IDENLEN); /* Truncate string  */
   code=findcode(buff,setcmd,setcmdlen);
   switch(code)
   {
     case 1 :
            puts("SET DEVICE PARAMETER - NOT IMPLEMENT");
            break;
     case 2 :
            setnode(argv[2],argv[3]);
```

```
            break;
      default :
            puts("INCORRECT PARAMETER FOR SET COMMAND");
   }
}
/*
 *
 *   Dos command  eg. DIR,TYPE,DEL,COPY
 *
 */

void dirmain(argc,argv)
int argc;
char *argv[];
{
   if (argc==1)
     {
        dir("*.LAP");
        return;
     }
   if (argc==2)
     {
       dir(argv[1]);
       return;
     }
   puts("SYNTAX ERROR!");
}

void pause(argc,argv)
int argc;
char *argv[];
{
   if (argc ==1) { waitkey(); return;}
   if (argc ==2)  sleep(atoi(argv[1]) );
}

LOCAL void showfreemem()
{
    unsigned long memory;
    memory=memavail();
    printf("memory available:%10ld Byte\n",memory );
}
void delmain(argc,argv)
int argc;
char *argv[];
{
   if (argc !=2) return;
   delfile(argv[1]);
}
void typemain(argc,argv)
int argc;
char *argv[];
{
   if (argc !=2) return;
   typefile(argv[1]);
}
void copymain(argc,argv)
int argc;
char *argv[];
{
```

```
   if (argc != 3) return;
   copyfile(argv[1],argv[2]);
}

/*-----------------------*
   New circuit command
 *-----------------------*/
LOCAL void newcircuit()
{
     freegate();
     freenode();
     freesrc();
     freemacro();
     free_usr_model();
     initdata();
     initdpmodule();
}

/*-----------------------------*
    M A I N    P R O G R A M
 *-----------------------------*/

/*    Share Variable in lapmain */

LOCAL  char       *prompt ="LAP>";
LOCAL  char       pathname[40];
LOCAL  char       *argv[MAXARGUMENT];
LOCAL  int        argc;
LOCAL  char       cmdbuffer[20][20];
LOCAL  char       linebuff[256];   /* Command input buffer */


LOCAL void initmain()
{
    int i;

    /* Reserve area for argument string */
    for(i=0;i<20;i++)
      argv[i]  = cmdbuffer[i];
    /*  Make Vcc and GND node */
    makerefnode();
    /* Init routine that handle data structure  */
    initdata();
    initdpmodule();
    create_tq();    /* create time queue */
    showfreemem();
}

/* This routine fetch command string from user */
int  fetch(argv)
char *argv[];
{
     IMPORT char *prompt,linebuff[];
     int argc;

     for(argc=0; (argc=strargv(getcmdln(prompt,linebuff) , argv))==0;);
     return(argc);
}

int cmdexec(argc,argv)
```

```
int argc;
char *argv[];
{
static CMDTABLE  cmdtab[]={
                        {"QUIT",1},{"EXIT",1},
                        {"LIST",2},{"SIM" ,3},
                        {"DISP",4},{"SAVE",5},
                        {"LOAD",6},{"DEFI",7},
                        {"HELP",9},{"ED",8},
                        {"NEW",11},{"MEM",10},
                        {"SET",13} ,{"DIR",14},
                        {"PAUS",15},{"DEL",16},
                        {"TYPE",17},{"COPY",18}
                          };
static int      cmdtablen = sizeof(cmdtab)/sizeof(CMDTABLE);
static char buff[CMDLEN+2];
static int code;

      /* Command in LAP use only first CMDLEN character */
      strtrunc(buff,argv[0],CMDLEN);  /* Truncate string */
      code=findcode(buff,cmdtab,cmdtablen);
      /*  Command switching   */
      switch(code)
       {
        case  1  : break;   /* exit and quit command */
        case  2  :
                   listmain(argc,argv);
                   break;
        case  3  :
                   simmain(argc,argv);
                  break;
       case  4  :
                  displaymain(argc,argv);
                  break;
       case  5  :
                  savemain(argc,argv);
                  break;
       case  6  :
                  loadmain(argc,argv);
                  break;
       case  7  :
                  puts("DEFINE NOT IMPLEMENT NOW");
                  break;
       case  8  :
                  printf("EDIT>"); getch();
                  printf("\n");
                  break;
       case  9  :
                  helpmain();
                  break;
       case 10  :
                  showfreemem();
                  break;
       case 11  :
                  newcircuit();
                  break;
       case 13  :
                  setupmain(argc,argv);
                  break;
       case 14  :
```

```
                dirmain(argc,argv);
                break;
        case 15  : pause(argc,argv);
                break;
        case 16  : delmain(argc,argv);
                break;
        case 17  : typemain(argc,argv);
                break;
        case 18  : copymain(argc,argv);
                break;
        default  :
                puts("Invalid command!\07");
         }
       return(code);   /* Return action code to caller */
}

#define  EXIT_ACTION              1

#ifdef   UNIX
void brk_sig()
{
   char ans;

   printf("Press Y to abort program:");
   ans=getchar();
   if (ans=='Y')
     {
       printf("Program terminate by user!!\n");
       exit(1);
     }
}
#endif

void main()
{
    int  action;

#ifdef  UNIX
    ssignal(SIGINT,brk_sig);
#endif
    title();
    initmain();
    do {
      argc=fetch(argv);
      action=cmdexec(argc,argv);
    } while ( action != EXIT_ACTION);  /* Action code 1 is exit action */
    newcircuit();  /* Clear all circuit */
    printf("** End Logic Analysis Program LAP1.0 **\n");
    exit(0);
}
```

```
/*
 *  MODULE: LAPEDIT
 *  AUTHOR: P.Uthayopas
 *  DATE:
 *
 *       This module get user circuit script from file
 *  and add to data structure
 */
#include  <stdio.h>
#include  <string.h>
#include  <mem.h>
#include "lap.h"
#include "lapdata.h"
#include "laputil.h"
#include "lapedit.h"
#include "lapeval.h"
#include "lapmacro.h"

#define   COMMENTCHAR     '*'
#define   NORMAL_MODEL    1
#define   MACRO_MODEL     2
#define   GARBAGE_MODEL   3
/*--------------------*
   E D I T   M A I N
 *--------------------*/

static  char  line[255];    /* Input buffer */
FILE    *network;           /* Input file   */
/* PUBLIC NAMESTR circuitname; */ /* name of this circuit */

/*
 *   Internal function
 */
#ifdef  IBMPC
LOCAL  void  editsrc(int argc,char *argv[]);
LOCAL  void  editclk(int argc,char *argv[]);
LOCAL  void  editgate(int argc,char *argv[]);
LOCAL  void  editbus(int argc,char *argv[]);
LOCAL  void  editmodel(int argc,char *argv[]);
LOCAL  void  editnode(int argc,char *argv[]);
LOCAL  LOGICMODEL  *chkelm(int argc,char *argv[]);
LOCAL  int   looktype(char *name,void **model);
LOCAL  void  normalgate(int argc,char *argv[],LOGICMODEL *m);
#else
  #ifdef UNIX
LOCAL  void  editsrc ();
LOCAL  void  editclk ();
LOCAL  void  editgate();
LOCAL  void  editbus();
LOCAL  void  editmodel();
LOCAL  void  editnode();
LOCAL  LOGICMODEL  *chkelm();
LOCAL  int   looktype();
LOCAL  void  normalgate();
  #endif
#endif

PUBLIC void editmain(argc,argv)
int argc;
char *argv[];
```

```
{
   static CMDTABLE gatecmd[]={
                {"SIG",1},{"SIGN",1},
                {"CLK",2},{"CLOC",2},
                {"BUS",3},{"NODE",4},
                {"MODE",5},{"MACR",6}
                        };
   static int   gatecmdlen = sizeof(gatecmd)/sizeof(CMDTABLE);

   static char buff[IDENLEN+2];
   int code;

   if (argc==0) then return; /* Do nothing for NULL argument */
   strtrunc(buff,argv[1],CMDLEN); /* Truncate string  */
   code=findcode(buff,gatecmd,gatecmdlen);
   switch(code)
   {
     case 1  :
             editsrc(argc,argv);
             break;
     case 2  :
             editclk(argc,argv);
             break;
     case 3  :
             editbus(argc,argv);
             break;
     case 4  :
             editnode(argc,argv);
             break;
     case 5  :
             editmodel(argc,argv);
             break;
     case 6  :
             editmacro(argc,argv);
             break;
     default :
             editgate(argc,argv);
   }
}
void editsrc(argc,argv)
int argc;
char *argv[];
{
    LOGICSOURCE *p;
    char sname[10];
    int i;

    if (argc != 4) then {
      printf("<NAME> SIGNAL <OUTPUT NODE> <NO. OF BREAK POINT>\n"); return; }
    strtrunc(sname,argv[0],IDENLEN);
    p=getsrcptr(sname);  /* get pointer to source */
    p->stype=LSRC;
    p->index=0; p->tc=0;
    /* Maximum number of break point is MAXSBREAK */
    p->pnum= ( (p->pnum=atoi(argv[3])) > MAXSBREAK ? MAXSBREAK : p->pnum);
    strtrunc(sname,argv[2],IDENLEN);
    p->outnode=getnodeptr(sname);
    /* Read waveform */
    for(i=0;i<p->pnum;i++) {
         fetchstr(line);
```

```
        strargv(line,argv);
        p->time[i]=atoi(argv[0]);
        p->state[i]=tologic(*argv[1]);
        printf("%5d%5s\n",p->time[i],argv[1]);
      }
}

void editclk(argc,argv)
int argc;
char *argv[];
{
    LOGICSOURCE *p;
    char sname[10];
    int ton,toff;

    if (argc != 5) then {
       printf("<NAME> CLOCK <OUTPUT NODE> <Ton ns> <Toff ns>\n"); return; }
    strtrunc(sname,argv[0],IDENLEN);
    p=getsrcptr(sname);  /* get pointer to source */
    p->stype=CLKSRC;
    p->index=0; p->tc=0;
    p->pnum=2;
    p->state[0]=LOW; p->state[1]=HIGH;
    p->time[0]=atoi(argv[4]);  /* T  on */
    p->time[1]=atoi(argv[3]);  /* T off */
    p->outnode=getnodeptr(argv[2]);
}

void editbus(argc,argv)
int argc;
char *argv[];
{
    LOGICELEMENT *p;
    LOGICMODEL   *m;
    char busname[10];
    register i,index;
    int fanin;

    if (argc<3) then
      {
        printf("<BUSNAME> BUS <INPUT 1..n> <OUTPUT>\n ");
        printf("<BUSNAME> BUS <Time delay (nSec) >");
      }
    if (argc > 3) /* ADD NEW BUS ELEMENT */
     {
        m=getmodelptr(argv[1]);
        fanin=argc-3;
        if(fanin > m->inum)
          {   printf("ERROR! TOO MUCH BUS FAN-IN,MAXIMUM=%d\n",m->inum);
              return;
          }
        strtrunc(busname,argv[0],IDENLEN);
        if ((p=oldgate(busname))!=NULL)
          {  printf("BUS %s ALREADY EXIST!\07\n",busname);
             return; }
        p=getgateptr(busname);
        p->inum=fanin;
        p->model=m;
        p->onum=m->onum; /* Bus output is 1 pin      */
        p->td=m->td;     /* Set bus delay to default */
```

```
        index=2;
        /* init all fanin */
        for(i=0;i<p->inum;i++)
           { p->in[i]=getnodeptr(argv[index++] ); }
        /* init 1 fanout */
        p->out[0]=getnodeptr(argv[index]);
        p->ps=0;  /* Present state is 0 */
      }
    else /* SET BUS ELEMENT DELAY */
      {
       /* Force time delay minimum 1 ns */
        strtrunc(busname,argv[0],IDENLEN);
        if ((p=oldgate(busname)) !=NULL) {
           p->td= ( (p->td=atoi(argv[2])) > 0 ? p->td : 1 ); }
         else  printf("BUS %s DOES NOT EXIST!\07\n",busname);
      }
}
void  editmodel(argc,argv)
int argc;
char *argv[];
{

    LOGICMODEL *p,*m;
    char modelname[10];
    if (argc != 4 )
      {
        printf("<NAME> MODEL  <BUILD IN MODEL>  <Td>\n");
        return;
      }
    strtrunc(modelname,argv[0],IDENLEN); /* Truncate model name */
    if ((p=getmodelptr(modelname)) !=NULL)
      {
        printf("Model already exist,redefine fail!\n");
        return;
      }
    if ((p=getmodelptr(argv[2])) ==NULL)
      {
        printf("Please choose correct build in model to copy !\n");
        printf("<NAME> MODEL  <BUILD IN>  <Td>\n");
        return;
      }
    m=dupmodel(p);
    strcpy(m->name,modelname);
    /* Allow timedelay = 0 for testing */
    m->td=( (m->td=atoi(argv[3])) >=0 ? m->td : 1);
    add_usr_model(m);
}

void  editnode(argc,argv)
int argc;
char *argv[];
{
    LOGICNODE *p;

    if (argc !=3)
      {  puts("<NAME>  NODE  <LOGIC STATE>");
         return; }
    p=getnodeptr(argv[0]);
  /* Convert first char of argv[2] to logic state */
```

```
    p->state=tologic(*argv[2]);
}

void  normalgate(argc,argv,m)
int argc;
char *argv[];
LOGICMODEL *m;
{
    LOGICELEMENT *p;

    char gatename[10];
    register i;
    int index,x;

    x=argc - (m->inum + m->onum) ;
    if (! ( (x<2) || (x>3) )) then
     {   /* Syntax checking passed */
         strtrunc(gatename,argv[0],IDENLEN);
         if ( oldgate(gatename) != NULL)
           {  printf(" GATE EXIST! NOT ALLOW TO REDEFINE\07\n");
              return; }
         p=getgateptr(gatename);
         p->model=m;
         p->inum=m->inum;
         p->onum=m->onum;
         if ((argc - m->inum - m->onum)==3) /* User define time delay */
           {  /* Force time delay minimum 1 ns */
              p->td= ( (p->td=atoi(argv[argc-1])) > 0 ? p->td : 1 );
           }
         else p->td=m->td;  /* If not def use default time delay */
         index=2;
         /* init all fanin */
         for(i=0;i<p->inum;i++)
           { p->in[i]=getnodeptr(argv[index++] ); }
         /* init all fanout */
         for(i=0;i<p->onum;i++)
           { p->out[i]=getnodeptr(argv[index++]); }
         p->ps=0; /* Present state is 0 */
     }
     else printf("<GATENAME> <MODELS> <IN 1..n> <OUT 1..n> [delay]\n");
}

int   looktype(name,model)
char *name;
void **model;
{
       void *m;
       if (( m=(void *)getmodelptr(name) )!=NULL)
         {
           *model=m;  return(NORMAL_MODEL);
         }
       if (( m=(void  *)getmacroptr(name)) !=NULL)
         {
            *model=m; return(MACRO_MODEL);
         }
       *model=NULL;
       return(GARBAGE_MODEL);
}

void  editgate(argc,argv)
```

```
int argc;
char *argv[];
{
     void *model;
    char modelname[10];

    /* Truncate name to IDENLEN */
     strtrunc(modelname,argv[1],IDENLEN);
     switch(looktype(modelname,&model) )
      {
        case NORMAL_MODEL   :
                        normalgate(argc,argv,(LOGICMODEL *)model);
                        break;
        case MACRO_MODEL    :
                        expandmacro(argc,argv,(MACRO *) model);
                        break;
      }
}
/*---  END  OF  EDIT  FUNCTION ---*/

/*-------------------*
    File Handling
 *-------------------*/
void  lapread();
void  lapwrite();

void  lapfile(command,buff)
int command;
CMDFILE *buff;
{
       switch(command)
       {
        case  READ :    lapread(buff);
                        break;
        case  WRITE :   lapwrite(buff);
                        break;
        default     :
            lapperr(INVALIDCMD);
        }
}
/*-----------------------*
    File reading function
 *-----------------------*/
PUBLIC int fetchstr(st)
char *st;
/* This function fetch a string from file return NULL if end of file */
{
   IMPORT FILE *network;
    *st=NULL;  /* first set string to NULL string */
   if (feof(network)==0)
     {/* Read file 1 line */
       fgets(st,200,network);
       strupr(st);
       return(1);
     }
    return(0);
}
LOCAL  void  lapread(buff)
CMDFILE *buff;
{
```

```
    CMDFILE *cmd;

    static  char argb[20][20];
    static  char *argv[20];
    static  int  argc;
    int i;

    cmd=(CMDFILE *)buff;
    for(i=0;i<20;i++) argv[i]=argb[i]; /* SET BUFFER */
    if (( network=fopen(cmd->fname,"r"))==NULL)
      {
        printf("FILE NOT FOUND!!\n");
        return;
      }
   printf("READ FILE: %s\n",cmd->fname);
   while( fetchstr(line) )
   {
       printf("%s",line);
       if ( *line !=COMMENTCHAR )      /* Skip comment line */
        {
          argc=strargv(line,argv);
          editmain(argc,argv);
        }
    }
  fclose(network);
}

/*-------------------------*
   F I L E   W R I T I N G
 *-------------------------*/

#ifdef  IBMPC
LOCAL void elmwrite(FILE *fp,char *name);
LOCAL void nodewrite(FILE *fp);
LOCAL void clkwrite(FILE *fp);
#endif

LOCAL  void  lapwrite(cmdptr)
CMDFILE *cmdptr;
{
   CMDFILE *cmd;
   int i;
   FILE *fp;

   cmd=(CMDFILE *)cmdptr;

   if (( fp=fopen(cmd->fname,"w"))==NULL)
     {
       printf("FILE OPEN ERROR!\n");
       return;
     }
   puts("*** CIRCUIT NODE STATE WRITING ***");
/*
   elmwrite(fp,cmd->fname);
   clkwrite(fp);
*/
   nodewrite(fp);

   fclose(fp);
}
```

```
/*-----------------------------------------*
   elmwrite and clkwrite are not used now
 *-----------------------------------------*/
void elmwrite(fp,name)
FILE *fp;
char *name;
{
   LOGICELEMENT *p;
   register i;

   fprintf(fp,"%8s%8s\n",name,"CIRCUIT");
   LOOPLIST(p,elmhead)
   {
    fprintf(fp,"%8s%8s",p->name,p->model->name);
    for(i=0;i <p->inum;i++) fprintf(fp,"%*s",IDENLEN+1,p->in[i]->name);
    for(i=0;i <p->onum;i++) fprintf(fp,"%*s",IDENLEN+1,p->out[i]->name);
    fprintf(fp,"%*d\n",IDENLEN,p->td);
    }
}

void nodewrite(fp)
FILE *fp;
{
  LOGICNODE *node;

  fprintf(fp,"*--------------------*\n");
  fprintf(fp,"*    Logic state     *\n");
  fprintf(fp,"*--------------------*\n");
  LOOPLIST(node,nodehead)
   {
     if (node->type==XTERN) {
     fprintf(fp,"%8s%8s%6c\n",node->name,"NODE",logictoc(node->state)); }
   }
}

void clkwrite(fp)
FILE *fp;
{
  LOGICSOURCE *s;
  register i;

  LOOPLIST(s,srchead)
    {
     fprintf(fp,"%8s",s->name);
     if (s->stype==CLKSRC)
       {
          fprintf(fp,"%8s%8s%4d%4d\n",
                "CLOCK",s->outnode->name,s->time[1],s->time[0]);
        /* writing Ton before Toff */
       }
     else {
     fprintf(fp,"%*s%*s%4d\n",IDENLEN+1,"SIGNAL",IDENLEN+1,
                              s->outnode->name,s->pnum);
     for(i=0;i<s->pnum;i++) {
          fprintf(fp,"%5d%5c\n",s->time[i],logictoc(s->state[i]));
         }
      }
    }  /* END loop source */
}
```

```
/*
 *  MODULE:    LAPDATA
 *  AUTHOR:    P.UTHAYOPAS
 *  DATE:
 *
 *      This module contain routine that handle linklist
 *  of circuit data.
 */
#include <stdio.h>
#include <string.h>
#include <alloc.h>
#include "lap.h"
#include "lapdata.h"
#include "lapeval.h"
#include "laputil.h"
#include "lapmacro.h"

/*
 * Internal use function
 */
#ifdef  IBMPC
LOCAL  void freegate(void);
LOCAL  void freenode(void);
LOCAL  void freesrc(void);
LOCAL  int  addsrc(LOGICSOURCE *p);
#else
  #ifdef  UNIX
LOCAL  void freegate();
LOCAL  void freenode();
LOCAL  void freesrc();
LOCAL  int  addsrc();
  #endif
#endif

PUBLIC  LIST  buf1;
PUBLIC  LIST  buf2;
PUBLIC  LIST  buf3;
PUBLIC  LIST  *elmhead = &buf1;   /* head of element link list */
PUBLIC  LIST  *nodehead= &buf2;   /* head of node    link list */
PUBLIC  LIST  *srchead = &buf3;   /* head of source  link list */

LOGICNODE  *vccptr,*gndptr;

LOCAL  void initelm()
{
/* Init element list */
    LENGTH(elmhead)=0;
    TAIL(elmhead)=NULL;
    HEAD(elmhead)=NULL;
}

LOCAL void initnode()
{
/*   Init node list    */
/*  puts("Init node link list"); */
    LENGTH(nodehead)=0;
    TAIL(nodehead)=nodehead;
    HEAD(nodehead)=NULL;
}
```

```
LOCAL void initsrc()
{
/* Init source list  */
/*    puts("Init source link list");  */
    LENGTH(srchead)=0;
    TAIL(srchead)=srchead;
    HEAD(srchead)=NULL;
}

LOCAL void initrefnode()
{    LOGICNODE *p;
     /* Initial vcc */
/*        puts("Init Vcc and GND"); */
        p=vccptr;
        p->inum=p->onum=0;
        p->state=HIGH;        /* set initial state of node */
        p->outstate[0]=LOW; /* set initial for op-table */
     /* Initial ground */
        p=gndptr;
        p->inum=p->onum=0;
        p->state=LOW;        /* set initial state of node */
        p->outstate[0]=LOW; /* set initial for op-table */
}
PUBLIC void makerefnode() /* CALL ONCE WHEN PROGRAM START */
{
  LOGICNODE *p;

/*      puts("Make reference node");  */
     /* Initialize VCC */
        if ( (p=malloc(sizeof(LOGICNODE))) ==NULL )
          { lapperr(MEMFAULT); exit(MEMFAULT); }
        p->in =(LOGICELEMENT **)calloc(MAXFANIN,sizeof(LOGICELEMENT *) );
        p->out=(LOGICELEMENT **)calloc(MAXREFOUT,sizeof(LOGICELEMENT *) );
        strcpy(p->name,"VCC"); /* set VCC name */
     /* Set out put state table */
        p->outstate=(LOGICSTATE *)calloc(MAXTIME,sizeof(LOGICSTATE) );
        vccptr=p;
     /* Initialize GND */
        p=(LOGICNODE *) malloc(sizeof(LOGICNODE));
        p->in =(LOGICELEMENT **)calloc(MAXFANIN,sizeof(LOGICELEMENT *) );
        p->out=(LOGICELEMENT **)calloc(MAXREFOUT,sizeof(LOGICELEMENT *) );
        strcpy(p->name,"GND"); /* set VCC name */
     /* Set out put state table */
        p->outstate=(LOGICSTATE *)calloc(MAXTIME,sizeof(LOGICSTATE) );
        gndptr=p;
}

PUBLIC void initdata()
{
   initelm();
   initnode();
   initsrc();
   initmacro();
   initrefnode();
}

/*--------------------*
   Clear data storage
 *--------------------*/
void freegate()
```

```
{
  LOGICELEMENT *p;
/*  printf("free gate\n");  */
  LOOPLIST(p,elmhead)
    {
       free(p);  /* free this element */
    }
}
void freenode()
{
  LOGICNODE *p;
/*  printf("free node\n"); */
  LOOPLIST(p,nodehead)
   {
     /* free output table */
     if (p->outstate !=NULL) free(p->outstate);
     free(p->in);  /* Free fanin table */
     free(p->out); /* Free fanout table */
     free(p);
   }
}
void freesrc()
{
  LOGICSOURCE *p;
/*  printf("free source\n");  */
  LOOPLIST(p,srchead)
     free(p);
}
PUBLIC int addelm(p)
LOGICELEMENT *p;
{
    LOGICELEMENT *last;

    last=(LOGICELEMENT *)TAIL(elmhead);
    p->next=NULL;
    if ( HEAD(elmhead) == NULL)  HEAD(elmhead) = p;
       else  last->next=p;
    TAIL(elmhead)=p;
    return(++LENGTH(elmhead));
}
PUBLIC int addnode(p)
LOGICNODE *p;
{
    LOGICNODE *last;

    last=(LOGICNODE *)TAIL(nodehead);
    p->next=NULL;
    if ( HEAD(nodehead)==NULL) HEAD(nodehead)=p;
      else last->next=p;
    TAIL(nodehead)=p;
    return(++LENGTH(nodehead));
}
LOCAL int addsrc(p)
LOGICSOURCE *p;
{
    LOGICSOURCE *last;

    last=(LOGICSOURCE *)TAIL(srchead);
    p->next=NULL;
    if ( HEAD(srchead)==NULL) HEAD(srchead)=p;
```

```
      else last->next=p;
    TAIL(srchead)=p;
    return(++LENGTH(srchead));
}

/*-------------------------------------
   Element existance checking
   for logicelement,node,logic source
   return: pointer to object if exist
           NULL if not found
 *-------------------------------------*/
PUBLIC LOGICELEMENT *oldgate(name)
char *name;
{
   LOGICELEMENT *p;
   for(p=(LOGICELEMENT *)HEAD(elmhead);
       (p != NULL) && (strcmp(p->name,name) !=0 );p=p->next) ;
     return(p);
}

PUBLIC LOGICSOURCE *oldsrc(name)
char *name;
{
   LOGICSOURCE *p;
    for(p=(LOGICSOURCE *) HEAD(srchead);
        (p !=NULL) && (strcmp(p->name,name) != 0);p=p->next);
    return(p);
}
PUBLIC LOGICNODE *oldnode(name)
char *name;
{
   LOGICNODE *p;
    for(p=(LOGICNODE *)HEAD(nodehead);
        (p !=NULL) && (strcmp(p->name,name) != 0);p=p->next);
    return(p);
}
/*-----------------------------------*
    Data allocation and retrieval
 *-----------------------------------*/
PUBLIC LOGICELEMENT *makenewgate(st)
char *st;
{       LOGICELEMENT *p;
        if ((p=malloc(sizeof(LOGICELEMENT)) )==NULL)
         { lapperr(MEMFAULT);  exit(MEMFAULT); }
        strcpy(p->name,st);
        return(p);
}
 /*  FUNC: getgateptr()
    USE:  get pointer to gate if exist,else allocate
          storage for new gate.
    RET:  pointer to LOGICELEMENT
 */
PUBLIC LOGICELEMENT *getgateptr(st)
char *st;
{
    LOGICELEMENT *p;
    int n;

    /* Allocate  new gate */
    p=makenewgate(st);
```

```
    p->type=XTERN;
    addelm(p);
    return(p);
}

PUBLIC LOGICNODE *makenewnode(st)
char *st;
{
        LOGICNODE *p;
        if ((p=malloc(sizeof(LOGICNODE)))==NULL)
          { lapperr(MEMFAULT); exit(MEMFAULT); }
        p->in =(LOGICELEMENT **)calloc(MAXFANIN,sizeof(LOGICELEMENT *) );
        p->out=(LOGICELEMENT **)calloc(MAXFANOUT,sizeof(LOGICELEMENT *) );
        strcpy(p->name,st); /* set node name */
        p->inum=p->onum=0;
        p->state=LOW;       /* set initial state of node */
        return(p);
}
/*
    FUNC: getnodeptr()
    USE:  get pointer to node if exist,else allocate
          storage for new node and return pointer.
    RET:  pointer to LOGICNODE
 */
PUBLIC LOGICNODE *getnodeptr(st)
char *st;
{
    LOGICNODE *p;
    int n;

    /* Reference node */
    if ( strcmp("VCC",st)==0 ) { return(vccptr); }
    if ( strcmp("GND",st)==0 ) { return(gndptr); }
    /* Normal node */
    p=oldnode(st);
    if (p==NULL) then /*  node not exist */
      {
        p=makenewnode(st);
        p->type=XTERN;
        p->outstate=(LOGICSTATE *)calloc(MAXTIME,sizeof(LOGICSTATE) );
        p->outstate[0]=0; /* set initial 0 */
        addnode(p);
      }
     return(p);
}
/*  FUNC: getsrcptr()
    USE:  get pointer to LOGICSOURCE if exist,else allocate
          storage for new source and return pointer.
    RET:  pointer to LOGICSOURCE
 */
PUBLIC LOGICSOURCE *getsrcptr(st)
char *st;
{
    LOGICSOURCE *p;
    int n;

    p=oldsrc(st);
    if (p==NULL) then /*  source not exist */
      {  /*  Create new source */
         if ((p=malloc(sizeof(LOGICSOURCE)))==NULL)
```

```
        { lapperr(MEMFAULT); exit(MEMFAULT); }
        strcpy(p->name,st); /* set source name */
        addsrc(p);
      }
    return(p);
}

PUBLIC void setnode(nodename,s)
char *nodename;
char *s;
{
    LOGICNODE *node;
    LOGICSTATE state;

    state=tologic(*s);
    if ( ! strcmp(nodename,"ALL") ) then
      {
        LOOPLIST(node,nodehead)
         {
            printf("SET NODE:%8s to %5s\n",node->name,s);
            node->state=state;
         }
        return;
      }
    else
      {
         if ( (node=oldnode(nodename)) != NULL)
          then {
             node->state=state;
             printf("SET NODE:%8s to %5s\n",node->name,s);
               }
            else   puts("INVALID NODE NAME !");
         return;
      }
}
```

```
/*-------------------------
   Circuit element listing
 *-------------------------*/
#include <stdio.h>
#include <string.h>
#include <alloc.h>
#include "lap.h"
#include "lapdata.h"
#include "laputil.h"

int     listgate(void);
int     listnode(void);
int     listclk(void);
void    listfio(void);

PUBLIC void  listmain(int argc.char *argv[])
{

static CMDTABLE  listab[]={
                        {"GATE",1},
                        {"SOURCE",2},
                        {"SIGNAL",2},
                        {"FIO" ,3},
                        {"NODE",4},
                        {"MODEL",5},
                        {"MACRO",6}
                          };
static int      listablen = sizeof(listab)/sizeof(CMDTABLE);
  int srcnum,gatenum,code;
  char cmdstr[10];

  if (argc >2 ) { lapperr(SYNTAXERR); return; }
  if (argc==1)
  {
    gatenum=listgate();
    srcnum =listclk();
    printf("\nTOTAL GATE:%4d SIGNAL:%4d\n",gatenum,srcnum);
    return;
  }
  strtrunc(cmdstr,argv[1],IDENLEN);
  code=findcode(cmdstr,listab,listablen);
  switch(code)
   {
     case 1 :   gatenum=listgate();
                printf("\nTOTAL GATE:%d\n",gatenum);
                break;
     case 2 :   srcnum=listclk();
                printf("\nTOTAL SIGNAL:%d\n",srcnum);
                break;
     case 3 :   listfio();
                break;
     case 4 :   listnode();
                break;
     case 5 :   listmodel();
                break;
     case 6 :   listmacro();
                break;
   }
}
```

```
/*-----------------------------------------*
    FIOLIST-Fanin fanout listing for all node
 *-----------------------------------------*/
LOCAL void listfio(void)
{
  LOGICNODE *p;
  int i;

  LOOPLIST(p,nodehead)
   {
      if (p->type==XTERN)
      {
      printf("NODE: %s\n",p->name);
      for(i=0;i < p->inum;i++)  /* set fanin   */
        { printf("\t\tFAN  IN# %2d->GATE:%s\n",i+1,p->in[i]->name); }
      for(i=0;i < p->onum;i++)   /* set fanout */
        { printf("\t\tFAN OUT# %2d->GATE:%s\n",i+1,p->out[i]->name); }
      }
   }
}

LOCAL int listgate(void)
{
  LOGICELEMENT *p;
  int i;

   LOOPLIST(p,elmhead)
   {
/*    if (p->type ==XTERN)      */
     {
    printf("%8s%8s%6d ns ",p->name,p->model->name,p->td);
    for(i=0;i <p->inum;i++) printf("%8s",p->in[i]->name);
    for(i=0;i <p->onum;i++) printf("%8s",p->out[i]->name);
    printf("\n");
      }
    }
  return(elmhead->num);
}

LOCAL int listnode(void)
{
  LOGICNODE *p;
  printf("%9s%9s\n","NODE","STATE");
  LOOPLIST(p,nodehead)
  {
    if (p->type ==XTERN) /* list only external node */
    printf("%9s%9c\n",p->name,logictoc(p->state));
  }
  return(nodehead->num);
}

LOCAL int listclk(void)
{
  LOGICSOURCE *p;
  int i;

  LOOPLIST(p,srchead)
    {
     printf("%8s",p->name);
     if (p->stype==CLKSRC)
```

```
      {
       printf("%8s","CLOCK");
       printf("%8s  ",p->outnode->name);
       printf("Ton:%-4dns Toff:%-4dns\n",p->time[1],p->time[0]);
      }
     else {
     printf("%8s","SIGNAL");
     printf("%8s\n",p->outnode->name);
     for(i=0;i<p->pnum;i++)
        printf("%8d%8c\n",p->time[i],logictoc(p->state[i]));
      }
    }
  return(srchead->num);
}
```

```
/*
 *  MODULE: LAPSIM
 *  AUTHOR: P.Uthayopas
 *
 *      This  module perform simulation function.
 */
#include        <stdio.h>
#include        <alloc.h>
#include        <string.h>
#include        "lap.h"
#include        "lapcmd.h"
#include        "lapdata.h"
#include        "lapeval.h"

/*
 *  Local data structure for time queue
 *  use only in this module.
 */
typedef    struct tqnodetag   TQNODE;
typedef    struct timequeue   TIMEQUEUE;
struct tqnodetag {
                   LOGICNODE   *node;
                   LOGICSTATE  state;  /* For evaluation */
                   BYTE        status; /* For state recording */
                   struct tqnodetag *next;
                 };

struct timequeue{
         TQNODE  *first,*last;
         int     num;
       } ;
TIMEQUEUE   *timeq;
/*
 *   PUBLIC FUNCTION
 */
PUBLIC void simulator(CMD_SIM *simcmd);
/*
 *  INTERNAL FUNCTION
 */

/*
 * 1. time queue data management
 */
LOCAL void  add_to_tq(  LOGICNODE *node,
                        LOGICSTATE newstate,
                        BYTE status,
                        int mrt);

/*
 * 2. simulation routine
 */
LOCAL  void  sch_node(TQNODE *p,int mrt);
LOCAL  void  sch_src(int mrt);
LOCAL  void  dupoldstate(int mrt);
LOCAL  void  simulate(CMD_SIM *cmdptr);
/*
 *  Share variable
 */
PUBLIC  int             mrt;            /* Simulation time step    */
PUBLIC  int             usrtime;        /* Real time  from user    */
PUBLIC  BOOLEAN         isnewsim=TRUE;  /* True if new simulation  */
```

```
/*
 *    Time queue Handler
 */

/*
 *  add TQNODE into link list
 */
LOCAL void  addtqnode(int mrt,TQNODE *p)
{
   ++timeq[mrt].num;  /* Increment event count */
   p->next=NULL;
   if (timeq[mrt].first==NULL) /* Is first TQNODE ? */
      timeq[mrt].first=p;
     else  timeq[mrt].last->next=p;
   timeq[mrt].last=p;
}
/*
 *  get_tqdata  : pop data out of time queue
 *  RETURN:  Ptr to TQNODE
 *           NULL if queue empty
 */
LOCAL TQNODE  *get_tqnode(int time)
{
    TQNODE *p;
    if ( (p=timeq[time].first) !=NULL) {
          --timeq[time].num;
           timeq[time].first=p->next; }
    return(p);
}
LOCAL int get_tqlen(int mrt)
{
     return(timeq[mrt].num);
}
/*
 *  Create TQNODE and add in to time queue
 */
void  add_to_tq(LOGICNODE  *node,LOGICSTATE newstate,BYTE status,int mrt)
{
   TQNODE  *p;
   if ( mrt < MAXTIME)
   {
#if defined(DEBUGSIM)
   printf("TQADD node=%s t=%d st=%d\n",node->name,mrt,newstate);
#endif
   p=(TQNODE *)malloc(sizeof(TQNODE) ); /* MAKE TQNODE */
   p->node=node;                        /* INIT VALUE  */
   p->state=newstate;
   p->status=status;     /* Use for display only */
   addtqnode(mrt,p);
   }
}

void  clear_tq()
{
    register  i;
   /* clear time queue control */
    for(i=0;i< MAXTIME;i++)
       { timeq[i].num=0; timeq[i].first=timeq[i].last=NULL; };
}
```

```
void  create_tq()
{
   /* Create time queue call once when loading program */
   timeq=calloc(MAXTIME,sizeof(TIMEQUEUE));
}
/*--- END TIME QUEUE HANDLER ---*/

/*-------------------------*
    Display data handler
 *-------------------------*/
void  record_state(int mrt)
{
  LOGICNODE *p;

  LOOPLIST(p,nodehead)  /* Scan all node */
    { /* Record state only external node */
      if (p->type==XTERN) p->outstate[mrt]=p->state;
    }
}
/*-----------------------------*
     S I M U L A T I O N
 *-----------------------------*/

/*
 *       kick_node
 *  This routine schedule all node in time queue
 *  when simualtion start.
 *
 */
void kick_node(int time)
{
  LOGICNODE *p;

  /* on simulation start  schdule all node in time queue */
  LOOPLIST(p,nodehead)  /* Scan all node 1 time*/
   {
        add_to_tq(p,p->state,EVAL_NORMAL,time);
   }
}
/*
 *                  sch_node
 *   When accept time queue node,this routine scan
 *   all output node and calling evaluation function
 *   for each gate that it drive.Then,check output
 *   change with algorithm used and schedule output
 *   that will change in the future into timequeue.
 */
void sch_node(TQNODE *p,int mrt)
{
static LOGICSTATE optab[MAXOPIN]; /* Buffer for output table */
static LOGICSTATE iptab[MAXIPIN]; /* Buffer for input table  */

   LOGICNODE *node,*gnode;
   LOGICELEMENT *gate;
   LOGICSTATE   prestate,newstate;
   int fanout,fanin,outpin,newtime;
   int i;
   int err_stat;  /*  error status return from logic evaluation module */
   BYTE  status;  /*  Logic status for display                         */
```

```
    node=p->node;
    /* Update real node in circuit */
    node->state=p->state;
    if (node->simcount>0)  { --(node->simcount); }
    for(fanout=0;fanout< node->onum;fanout++) /* Scan all fanout */
     {
        gate=node->out[fanout];
        /* FIND LOGIC OUTPUT */
        /* Prepare input vector */
        for(fanin=0;fanin < gate->inum;fanin++)
           { iptab[fanin]=gate->in[fanin]->state; }
        err_stat=findlogic(gate,iptab,optab);
        status=0; /* Node evaluation status */
        if (err_stat==BUS_CONTENSION) {
            printf("BUS CONTENSION NODE=%6s,TIME=%5d\n",
                    gate->out[0]->name,usrtime);
            status=BUS_CONTENSION;
          }
        if (err_stat==SEQN_NO_TRIG) /* This element is block */
          return; /* No further processing */
        /* Scan all element output */
        for( outpin=0;outpin < gate->onum;outpin++)
         {
            gnode=gate->out[outpin];
            newtime=mrt+gate->td;
            prestate=gnode->state;
            newstate=optab[outpin];
            if (gnode->simcount >0 ) then
             {
                printf("* SPIKE * TIME:%4d NODE:%s\n",usrtime,gnode->name);
                ++(gnode->simcount);
                status |=SPIKE_DETECT;
                add_to_tq(gnode,newstate,status,newtime);
                return;
             }
            /* case Simcount  is 0 */
            if (prestate !=newstate)  /* if state change */
               {
                 ++(gnode->simcount);
                 add_to_tq(gnode,newstate,status,newtime);
                }
             else {
#if  defined(DEBUGSIM)
                    printf("BLOCKED node=%s\n",gnode->name);
#endif
                }
         }
     }
}
/*
 *              sch_src
 *    Check and process logic source in network.
 *
 */

void  sch_src(int mrt)
{
   LOGICSOURCE *p;
   LOGICSTATE  newstate,prestate;
   LOGICNODE   node;
```

```
   /* for all source */
   LOOPLIST(p,srchead)
      {
      if (p->tc >= p->time[p->index])
         {
           p->tc=0;
           ++(p->index);
           if ( p->index >= p->pnum) p->index=0;
         }
      newstate=p->state[p->index];
      if  ( p->state[p->index] != p->outnode->state )  /* STATE CHANGE */
           add_to_tq(p->outnode,newstate,EVAL_NORMAL,mrt);
      ++(p->tc);
   }
}
/*
 *          simulate
 *   Get command from simulation main and simulate
 *   circuit operation.
 *
 */
void  simulate(CMD_SIM *cmdptr)
{
   int i,tqlen,fullslot;
   TQNODE *p;

   printf("** SIMULATOR **\n\n");
   printf("SIMULATION START TIME:%5d LENGTH:%5d\n",
            usrtime,cmdptr->timelen);
   mrt=0;
   fullslot=0; /* Active time queue slot counter */
   /* Power on add VCC and GND to time queue */
   if ( isnewsim==TRUE)
    {   puts("** POWER ON **");
        add_to_tq(vccptr,HIGH,EVAL_NORMAL,mrt);
        add_to_tq(gndptr,LOW,EVAL_NORMAL,mrt);
    }
    /* schdule node with no fanin into time queue */
    kick_node(mrt);
    do
    {
#if defined(DEBUGSIM)
      printf("MRT:%3d TIME:%d\n",mrt,usrtime);
#endif
      sch_src(mrt);  /* Scheduling all source change */
      if ( (tqlen=get_tqlen(mrt)) !=0) {
         ++fullslot;
#if defined(DEBUGSIM)
         printf("MRT=%03d TIME QUEUE LENGTH=%4d\n",mrt,tqlen);
#endif
         }
      while ( ( p=get_tqnode(mrt)) !=NULL)   /* do while queue not empty */
        {
#if  defined(DEBUGSIM)
          printf("do node:%8s time=%d\n",p->node->name,mrt);
#endif
          sch_node(p,mrt);
          free(p);
        }
      record_state(mrt);     /*  record state of all node */
```

```
        ++mrt;  ++usrtime;     /*  GOTO NEXT TIME          */
     } while (mrt < cmdptr->timelen);
    printf("\n** Simulation complete **\n");
    printf("Active time queue slot=%4d\n",fullslot);
}

/*
 *  set node fanin fanout to correct position in network
 */
 LOCAL void preprocess()
{
    LOGICELEMENT *p;
    LOGICSOURCE  *q;
    LOGICNODE *node;
    int i;

    LOOPLIST(node,nodehead) { /* for all node */
         node->inum=node->onum=0; /* CLEAR NODE FANIN-OUT */
         node->simcount=0;        /* Init simulation counter */
      }
    LOOPLIST(p,elmhead) { /*    for all gate     */
       p->cks=LOW;        /* state of clock now */
       for(i=0;i < p->inum;i++)  /* set fanin    */
          { node=p->in[i];  node->out[(node->onum)++]=p; };
       for(i=0;i < p->onum;i++)   /* set fanout */
          { node=p->out[i];  node->in[(node->inum)++]=p; };
     }
}

LOCAL void  simsetup(CMD_SIM *simcmd);
LOCAL void  simfirst(CMD_SIM *simcmd);
LOCAL void  simcont(CMD_SIM *cmd);

void  init_old_sim(void)
{
     LOGICNODE   *p;
     LOGICSOURCE *s;

     isnewsim=FALSE;
     clear_tq();
}
void  init_new_sim(void)
{
     register   i,j;
     LOGICNODE   *p;
     LOGICSOURCE *s;

   puts("** INITIALIZE NEW SIMULATION **");
   usrtime=0;
   isnewsim=TRUE;
    /* Initial value for all source */
    LOOPLIST(s,srchead)
    {
       s->index=0;
       s->tc=0;
    }
    clear_tq();
}
 /* Simulation control parameter */
LOCAL   CMD_SIM         simparam={MAXTIME,SIM_NEW};
```

```
/*-------------------------------------*
   simsetup  - setup simulation parameter
 *-------------------------------------*/
void  simsetup(CMD_SIM *simcmd)
{
    memcpy(&simparam,simcmd,sizeof(CMD_SIM) );
}
/*-----------------------------------
    SIMCONT continue old simulation
 *-----------------------------------*/
void  simcont(CMD_SIM *cmd)
{
   puts("*** CONTINUE SIMULATION ***");
   init_old_sim();
   simulate(cmd);
}
/*-------------------------------------*
     SIMFIRST   start new simulation
 *-------------------------------------*/
void  simfirst(CMD_SIM *simcmd)
{
   init_new_sim();
   preprocess();
   simulate(simcmd);
}
/*
 *      S I M U L A T O R
 *   This module is entry point module for simulation.
 */
PUBLIC void simulator(CMD_SIM *simcmd)
{
    extern int evalcount;
    evalcount=0;
    switch(simcmd->cmd)
      {
         case SIM_SETUP  :  simsetup(simcmd);      break;
         case SIM_NEW    :  simfirst(&simparam);   break;
         case SIM_CONT   :  simcont(&simparam);    break;
      }
   printf(" TOTAL GATE PROCESSED=%5d\n",evalcount);
}
```

```
/*-------------------------------------------------*
  LOGIC STATE EVALUATION MODULE FOR LAP 1.1

 NOTE: This evaluation function assumed that all
 build-in gate is TTL-Logic gate.All input
 with ZSTATE  (High-IMPEDANCE MODE ) was
 transform to HIGH according to our assumption.
 *-------------------------------------------------*/
#include <stdio.h>
#include <alloc.h>
#include <mem.h>
#include "lap.h"
#include "lapeval.h"
#include "lapdata.h"

PUBLIC int evalcount=0;  /* Number of calling to find logic function */
extern int modelnum;     /* Number of build in model */
extern LOGICMODEL  gatemodel[];  /* Array of build in model */
/*-------------------------*
   Logic models function
 *-------------------------*/
LOCAL struct listnode usrlisbuff={NULL,NULL,0},*usrlist=&usrlisbuff;

/* duplicate model */
PUBLIC LOGICMODEL *dupmodel(LOGICMODEL *p)
{
    LOGICMODEL *m;
    m=(LOGICMODEL *)malloc(sizeof(LOGICMODEL));
    memcpy(m,p,(unsigned)sizeof(LOGICMODEL));
    return(m);
}
PUBLIC void free_usr_model()
{
   LOGICMODEL *p;

   for(p=HEAD(usrlist);p !=NULL;p=p->next)
     free(p);
   HEAD(usrlist)=TAIL(usrlist)=NULL;  /* Set all to empty list */
   LENGTH(usrlist)=0;
}
PUBLIC void add_usr_model(LOGICMODEL *p)
{
    LOGICMODEL *last;

    last=TAIL(usrlist);
    p->next=NULL;
    if (HEAD(usrlist)==NULL) /* if this is first user define model */
        HEAD(usrlist)=p;
     else  last->next=p;
    TAIL(usrlist)=p;
    ++LENGTH(usrlist);
}

LOCAL LOGICMODEL *scan_in_model(char *st)
{
     LOGICMODEL *m;
     int i;
     for(i=0,m=gatemodel;i<modelnum;i++,m++)
       {
          if (!strcmp(st,m->name) ) return(m);
```

```
        }
      return(NULL); /* NOT FOUND */
}
LOCAL LOGICMODEL *scan_usr_model(char *st)
{
       LOGICMODEL *p;

       for(p=HEAD(usrlist);p !=NULL;p=p->next) {
          if (!strcmp(st,p->name) ) return(p); }
      return(NULL); /* NOT FOUND */
}

PUBLIC LOGICMODEL *getmodelptr(char *st)
{
   LOGICMODEL *m;
   if ( (m=scan_in_model(st))==NULL)
     {  /* If not build in,scan for usr define model */
        return( scan_usr_model(st) );
     }
   return(m);
}
PUBLIC int listmodel()
{
     LOGICMODEL *m;
     int i,usrnum;

     puts("\t\tUSER DEFINED MODELS");
     printf("No.  %10s %4s %4s %4s\n","NAME","IN","OUT","DELAY");
     for(i=0,m=HEAD(usrlist);m !=NULL;m=m->next)
       {
         printf("<%2d> %10s %4d %4d %4d\n",++i,m->name,m->inum,m->onum,m->td);
       }
     usrnum=i;
     puts("\t\tBUILD IN MODELS");
     printf("No.  %10s %4s %4s %4s\n","NAME","IN","OUT","DELAY");
     for(i=0,m=gatemodel;i<modelnum;i++,m++)
       {
         printf("<%2d> %10s %4d %4d %4d\n",i+1,m->name,m->inum,m->onum,m->td);
       }
      printf("\t\tTOTAL: %5d Models\n",modelnum+usrnum);
      return(modelnum+usrnum);
}
/*-------------------------*
   Logic element evaluation
 *-------------------------*/

/*-------------------------------------------------
   DOCOMB - Procedure used to evaluate
            Standard Full table combination gate
 *-------------------------------------------------*/
LOCAL void docomb(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
    unsigned register i,index;
    /* Input[0] is left most bit */
    for(index=i=0;i<gate->inum;i++)
        index = (index << 2 ) | inpin[i];
    for(i=0;i< gate->onum;i++)
        outpin[i]= *( gate->model->op[i] + index);
}
/*---------------------------------------*
```

```
   Tricky Evaluation of build-in model
   AND,OR,NAND,NOR,INVERTER,DRIVER
 *-------------------------------------*/
LOCAL void do_and(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
/*  AND gate evaluate use INPUT COUNT METHOD */

    unsigned register i;

    /* Scan all input */
    for(i=0;i<gate->inum;i++) {
      switch(inpin[i])
       {
         case LOW     :  outpin[0]=LOW;      return;
         case UNKNOWN :  outpin[0]=UNKNOWN;  return;
       }
      }
    outpin[0]=HIGH;
    return;
}

LOCAL void do_nand(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
    unsigned register i,xcount;
    /* Scan all input */
    for(i=0;i<gate->inum;i++) {
      switch(inpin[i])
       {
         case LOW     :  outpin[0]=HIGH;      return;
         case UNKNOWN :  outpin[0]=UNKNOWN;  return;
       }
      }
    outpin[0]=LOW;
    return;

}

LOCAL void do_or(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
    unsigned register i;

    for(i=0;i<gate->inum;i++) {
      switch(inpin[i])
       {
         case HIGH    :  outpin[0]=HIGH;      return;
         case UNKNOWN :  outpin[0]=UNKNOWN;  return;
       }
      }
    outpin[0]=LOW;
    return;
}

LOCAL void do_nor(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
    unsigned register i,state;

    for(i=0;i < gate->inum;i++) {
      switch(inpin[i])
       {
         case HIGH    :  outpin[0]=LOW;      return;
```

```
        case UNKNOWN  :  outpin[0]=UNKNOWN;   return;
       }
      }
    outpin[0]=HIGH;
    return;
}

/*---------------------------------*
    Tri-state bus checking routine
 *---------------------------------*/
LOCAL int do_bus(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
    unsigned register i,index;
    LOGICSTATE state;

    state=ZSTATE;
    /* Scan all input */
    for(index=0,i=0;i<gate->inum;i++) {
       if ( inpin[i] != ZSTATE) {
          state = inpin[i];
          ++index; }
     }
    if (index>1) /* Bus contension detect when index >1 */
      {
       outpin[0]=UNKNOWN; /* Force output state to UNKNOWN */
       return(BUS_CONTENSION); /* return error status */
       }
    /* If there are only one input active */
    outpin[0]=state;
    return(EVAL_NORMAL);
}
/*
 *   Flip-flop and sequential circuit
 */
LOCAL int do_flp(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
        register i,index;
        LOGICSTATE pr,clr;
        int inmax,clkpin;
        BYTE state;
        /*
         *   preset clear alway the 2 rightmost pin
         */
        inmax=gate->inum-2;
        clr=inpin[gate->inum-1];
        pr =inpin[gate->inum-2];

        /* PRESET,CLEAR Checking */
        if ((pr==UNKNOWN)||(clr==UNKNOWN) )
         {
           gate->ps=outpin[0]=outpin[1]=UNKNOWN;
           return(EVAL_NORMAL);
         }
        if (clr== LOW)
          { /* CLEAR ACTIVE */
           gate->ps=outpin[0]=LOW;
           outpin[1]=HIGH;
           return(EVAL_NORMAL);
           }
         if (pr == LOW )
```

```
        { /* If preset */
          gate->ps=outpin[0]=HIGH;
          outpin[1]=LOW;
          return(EVAL_NORMAL);
        }
        /* check CLK trigger */

         clkpin=gate->model->clkpin;
            /* check CLK trigger */
         if (gate->cks == inpin[clkpin]) /* Clock not trig */
          { return(SEQN_NO_TRIG); }
          else
           {
             gate->cks=inpin[clkpin];/* store clock state */
           }
         /*
          *   normal flip-flop  logic finding
          */
        for(index=i=0;i< inmax;i++) {
          index = (index << 2 ) | inpin[i]; }
        index= index | (gate->ps << inmax*2);
        gate->ps=  *( gate->model->state + index );
        outpin[0]= *( (gate->model->op[0]) + index);
        outpin[1]= *( (gate->model->op[1]) + index);
        return(EVAL_NORMAL);
}
LOCAL int do_seqn(LOGICELEMENT *gate,LOGICSTATE *inpin,LOGICSTATE *outpin)
{
        register index,i;
        int clkpin;

        clkpin=gate->model->clkpin;
           /* check CLK trigger */
        if (gate->cks == inpin[clkpin]) /* Clock not trig */
           { return(SEQN_NO_TRIG); }
           else
            {
              gate->cks=inpin[clkpin];/* store clock state */
            }
    /* Full table sequential circuit */
        for(index=i=0;i<gate->inum;i++)
           index = (index <<2 ) | inpin[i];
        /* MASK Present state */
        index= index | (gate->ps << (gate->inum*2) );
        /* Find next state */
           gate->ps = *(gate->model->state + index);
         for(i=0;i< gate->model->onum;i++)
            outpin[i]= *( (gate->model->op[i]) + index);
         return(EVAL_NORMAL);
}

PUBLIC int findlogic(LOGICELEMENT *gate,
                     LOGICSTATE   *inpin,
                     LOGICSTATE   *outpin)
{       int status;
        register i;

        evalcount++;
        status=EVAL_NORMAL;
```

```
        if (gate->model->mmodel !=BUS)
        for(i=0;i<gate->inum;i++)
          { /* Convert input ZSTATE to HIGH */
             if (inpin[i]==ZSTATE ) inpin[i]=HIGH;
          }
/* Tricky type checking in order to apply dirty method to build in model */
        switch(gate->model->mmodel)
        {
           case COMB  : /* first,check build in combinational gate */
                        switch(gate->model->smodel)
                         {
                           case AND  :  do_and(gate,inpin,outpin);
                                        break;
                           case OR   :  do_or(gate,inpin,outpin);
                                        break;
                           case NAND :  do_nand(gate,inpin,outpin);
                                        break;
                           case NOR  :  do_nor(gate,inpin,outpin);
                                        break;
                           default   :  docomb(gate,inpin,outpin);
                         }
                        break;
           case FLPF  :
                        status=do_flp(gate,inpin,outpin);
                        break;
           case SEQN  :
                        status=do_seqn(gate,inpin,outpin);
                        break;
           case BUS   :
                        status=do_bus(gate,inpin,outpin);
                        break;
         }
        return(status);
}
```

```
#include <stdio.h>
#include "lap.h"
/*-----------------------------------------------*
   True table for build in element evaluation
 *-----------------------------------------------*/
/* STANDARD COMBINATIONAL ELEMENT */
  LOGICSTATE xortab[] =    {LOW,HIGH,UNKNOWN,HIGH,
                            HIGH,LOW,UNKNOWN,LOW,
                            UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                            HIGH,LOW,UNKNOWN,LOW};
 LOGICSTATE drvltab[]={ LOW,HIGH,UNKNOWN,ZSTATE,
                            ZSTATE,ZSTATE,ZSTATE,ZSTATE,
                            UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                            ZSTATE,ZSTATE,ZSTATE,ZSTATE};
 LOGICSTATE invtab[] ={HIGH,LOW,UNKNOWN,LOW};
 LOGICSTATE buftab[] ={LOW,HIGH,UNKNOWN,ZSTATE};

/* SEQUENTIAL ELEMENT */

/* Positive Edge trig flip-flop */
/*
 LOGICSTATE jkffq[]  ={0,0,0,0,0,1,0,1,1,1,1,0,1,1,1,0,1,0};
 LOGICSTATE jkffqb[] ={1,1,1,1,1,0,1,0,0,0,0,1,0,0,0,1,0,1};
 */
LOGICSTATE tfnq[]  =  {LOW,LOW,UNKNOWN,LOW,
                       HIGH,LOW,UNKNOWN,LOW,
                       UNKNOWN,LOW,UNKNOWN,LOW,
                       HIGH,LOW,UNKNOWN,LOW,
                       HIGH,HIGH,UNKNOWN,HIGH,
                       LOW,HIGH,UNKNOWN,HIGH,
                       UNKNOWN,HIGH,UNKNOWN,HIGH,
                       LOW,HIGH,UNKNOWN,HIGH,
                       UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                       UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                       UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                       UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN};

LOGICSTATE  tfnqb[]= {HIGH,HIGH,UNKNOWN,HIGH,
                      LOW,HIGH,UNKNOWN,HIGH,
                      UNKNOWN,HIGH,UNKNOWN,HIGH,
                      LOW,HIGH,UNKNOWN,HIGH,
                      LOW,LOW,UNKNOWN,LOW,
                      HIGH,LOW,UNKNOWN,LOW,
                      UNKNOWN,LOW,UNKNOWN,LOW,
                      HIGH,LOW,UNKNOWN,LOW,
                      UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                      UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                      UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                      UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN};
LOGICSTATE dfnq[]={
                          LOW,LOW,UNKNOWN,LOW,
                          HIGH,LOW,UNKNOWN,LOW,
                          UNKNOWN,LOW,UNKNOWN,LOW,
                          HIGH,LOW,UNKNOWN,LOW,
                          LOW,HIGH,UNKNOWN,HIGH,
                          HIGH,HIGH,UNKNOWN,HIGH,
                          UNKNOWN,HIGH,UNKNOWN,HIGH,
                          HIGH,HIGH,UNKNOWN,HIGH,
                          LOW,UNKNOWN,UNKNOWN,UNKNOWN,
                          HIGH,UNKNOWN,UNKNOWN,UNKNOWN,
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                        UNKNOWN,UNKNOWN,UNKNOWN,UNKNOWN,
                        HIGH,UNKNOWN,UNKNOWN,UNKNOWN,
                        LOW,HIGH,UNKNOWN,HIGH,
                        HIGH,HIGH,UNKNOWN,HIGH,
                        UNKNOWN,HIGH,UNKNOWN,HIGH,
                        HIGH,HIGH,UNKNOWN,HIGH
                    };
LOGICSTATE dfnqb[]={
                        HIGH,HIGH,UNKNOWN,HIGH,
                        LOW,HIGH,UNKNOWN,HIGH,
                        UNKNOWN,HIGH,UNKNOWN,HIGH,
                        LOW,HIGH,UNKNOWN,HIGH,
                        HIGH,LOW,UNKNOWN,LOW,
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                        HIGH,LOW,UNKNOWN,LOW,
                        LOW,LOW,UNKNOWN,LOW,
                        UNKNOWN,LOW,UNKNOWN,LOW,
                        LOW,LOW,UNKNOWN,LOW
                    };
LOGICSTATE dffq[]={
                    LOW,LOW,UNKNOWN,LOW,
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                    LOW,UNKNOWN,UNKNOWN,UNKNOWN,
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                    HIGH,UNKNOWN,UNKNOWN,UNKNOWN,
                    HIGH,HIGH,UNKNOWN,HIGH
};
LOGICSTATE  dffqb[]={
                    HIGH,HIGH,UNKNOWN,HIGH,
                    HIGH,LOW,UNKNOWN,LOW,
                    HIGH,UNKNOWN,UNKNOWN,UNKNOWN,
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                    LOW,LOW,UNKNOWN,LOW,
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```
};
LOGICSTATE  tffq[]={
                LOW,LOW,UNKNOWN,LOW,
                LOW,HIGH,UNKNOWN,HIGH,
                LOW,UNKNOWN,UNKNOWN,UNKNOWN,
                LOW,HIGH,UNKNOWN,HIGH,
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                HIGH,LOW,UNKNOWN,LOW,
                HIGH,UNKNOWN,UNKNOWN,UNKNOWN,
                HIGH,LOW,UNKNOWN,LOW,
                };

LOGICSTATE  tffqb[]={
                HIGH,HIGH,UNKNOWN,HIGH,
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                LOW,UNKNOWN,UNKNOWN,UNKNOWN,
                LOW,HIGH,UNKNOWN,HIGH,
                };
LOGICSTATE  jknq[]={
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                HIGH,LOW,UNKNOWN,LOW,
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                };

LOGICSTATE      jknqb[]={
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                HIGH,HIGH,UNKNOWN,HIGH,
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                };

LOGICSTATE jkpq[]={
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HIGH,LOW,UNKNOWN,LOW,
};

LOGICSTATE ikpqb[]={
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HIGH,HIGH,UNKNOWN,HIGH,
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                LOW,LOW,UNKNOWN,LOW,
                LOW,HIGH,UNKNOWN,HIGH,
                LOW,UNKNOWN,UNKNOWN,UNKNOWN,
                LOW,HIGH,UNKNOWN,HIGH,
                };

/*--------------------*
   DEFAULT GATE MODEL
 *--------------------*/

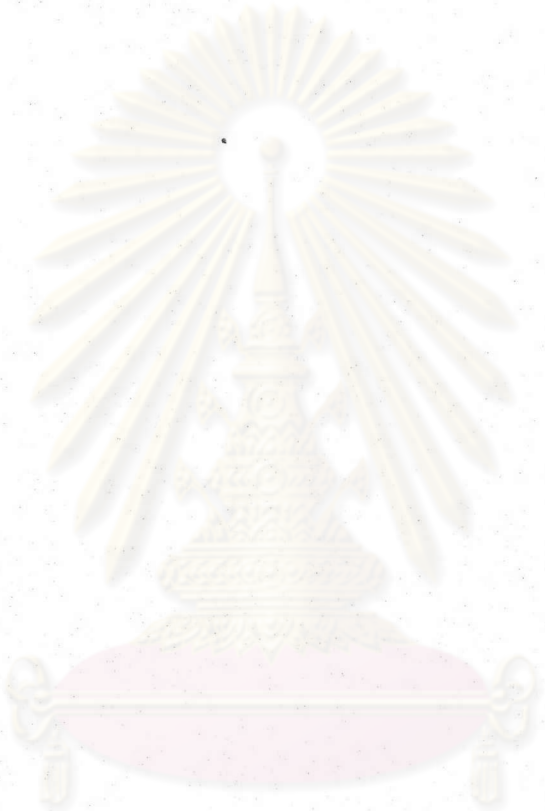
/*
 *  NOTE: all flip-flop use active low preset and clear input
 */.
PUBLIC LOGICMODEL gatemodel[]=  {
     { "AND2",AND,COMB,0,2,1,10,NULL ,NULL,NULL,NULL}, /* 74LS08 */
     { "AND3",AND,COMB,0,3,1,10,NULL ,NULL,NULL,NULL},
     { "AND4",AND,COMB,0,4,1,10,NULL ,NULL,NULL,NULL},
     { "AND5",AND,COMB,0,5,1,10,NULL ,NULL,NULL,NULL},
     { "AND6",AND,COMB,0,6,1,10,NULL ,NULL,NULL,NULL},
     { "AND7",AND,COMB,0,7,1,10,NULL ,NULL,NULL,NULL},
     { "AND8",AND,COMB,0,8,1,10,NULL ,NULL,NULL,NULL},

     { "OR2",OR,COMB,0,2,1,14,NULL,NULL,NULL,NULL},  /* 74LS32 */
     { "OR3",OR,COMB,0,3,1,14,NULL,NULL,NULL,NULL},
     { "OR4",OR,COMB,0,4,1,14,NULL,NULL,NULL,NULL},
     { "OR5",OR,COMB,0,5,1,14,NULL,NULL,NULL,NULL},
     { "OR6",OR,COMB,0,6,1,14,NULL,NULL,NULL,NULL},
     { "OR7",OR,COMB,0,7,1,14,NULL,NULL,NULL,NULL},
     { "OR8",OR,COMB,0,8,1,14,NULL,NULL,NULL,NULL},

     { "NAND2",NAND,COMB,0,2,1,10,NULL,NULL,NULL,NULL}, /* 74LS00 */
     { "NAND3",NAND,COMB,0,3,1,10,NULL,NULL,NULL,NULL},
     { "NAND4",NAND,COMB,0,4,1,10,NULL,NULL,NULL,NULL},
     { "NAND5",NAND,COMB,0,5,1,10,NULL,NULL,NULL,NULL},
     { "NAND6",NAND,COMB,0,6,1,10,NULL,NULL,NULL,NULL},
     { "NAND7",NAND,COMB,0,7,1,10,NULL,NULL,NULL,NULL},
     { "NAND8",NAND,COMB,0,8,1,10,NULL,NULL,NULL,NULL},

     { "NOR2",NOR ,COMB,0,2,1,10,NULL ,NULL,NULL,NULL}, /* 74LS02 */
     { "NOR3",NOR ,COMB,0,3,1,10,NULL ,NULL,NULL,NULL},
     { "NOR4",NOR ,COMB,0,4,1,10,NULL ,NULL,NULL,NULL},
     { "NOR5",NOR ,COMB,0,5,1,10,NULL ,NULL,NULL,NULL},
     { "NOR6",NOR ,COMB,0,6,1,10,NULL ,NULL,NULL,NULL},
     { "NOR7",NOR ,COMB,0,7,1,10,NULL ,NULL,NULL,NULL},
     { "NOR8",NOR ,COMB,0,8,1,10,NULL ,NULL,NULL,NULL},
/*  Standard combination evaluation element */
     { "INV" ,INV ,COMB,0,1,1,10,invtab ,NULL,NULL,NULL}, /* 74LS04 */
     { "XOR" ,XOR ,COMB,0,2,1,10,xortab ,NULL,NULL,NULL},
     { "BUFF",BUFF,COMB,0,1,1,10,buftab ,NULL,NULL,NULL},
     { "DRVL",DRIVER,COMB,0,2,1,10,drvltab,NULL,NULL,NULL},
     { "BUS" ,BUS   ,BUS ,0,20,1,10,NULL,NULL,NULL,NULL}, /* TRI-STATE BUS */
     /* Flip-flop with out preset and clear input */
     /* this model use standard sequential method to find logic */
     { "TFF"  ,TFF ,SEQN,1,2,2,15,tffq,tffqb,tffq,NULL},
     { "DFF"  ,DFF ,SEQN,1,2,2,25,dffq,dffqb,dffq,NULL},
     { "DFN"  ,DFF ,SEQN,1,2,2,25,dfnq,dfnqb,dfnq,NULL},
     { "TFN"  ,TFF ,SEQN,1,2,2,15,tfnq,tfnqb,tfnq,NULL},
     { "JKN" ,JKFF ,SEQN,2,3,2,15,jknq,jknqb,jknq,NULL},
     { "JKP" ,JKFF ,SEQN,2,3,2,15,jkpq,jkpqb,jkpq,NULL},
     /* Flip-flop with preset and clear input                    */
```

```
    /* use special subroutine to check preset and clear input */
    { "TFFC" ,TFF ,FLPF,1,4,2,15,tffq,tffqb,tffq,NULL},
    { "DFFC" ,DFF ,FLPF,1,4,2,25,dffq,dffqb,dffq,NULL},
    { "DFNC" ,DFF ,FLPF,1,4,2,25,dfnq,dfnqb,dfnq,NULL},
    { "TFNC" ,TFF ,FLPF,1,4,2,15,tfnq,tfnqb,tfnq,NULL},
    { "JKNC" ,JKFF,FLPF,2,5,2,15,jknq,jknqb,jknq,NULL},
    { "JKPC" ,JKFF,FLPF,2,5,2,15,jkpq ,jkpqb,jkpq,NULL}  /* 74LS76 */
                    };
/* Number of build in model */
PUBLIC int modelnum = (sizeof(gatemodel)/sizeof(LOGICMODEL) );
```



```
 /*--------------------------*
    Macro handling function
 *--------------------------*/
#include <stdio.h>
#include <string.h>
#include <alloc.h>
#include "lap.h"
#include "lapedit.h"
#include "laputil.h"
#include "lapeval.h"
#include "lapdata.h"
#include "lapmacro.h"
/*-----------------*
   PUBLIC FUNCTION
 *-----------------*/
PUBLIC void expandmacro(int argc,char *argv[],MACRO *m);
PUBLIC void editmacro(int margc,char *margv[]);
PUBLIC void listmacro(void);
PUBLIC void freemacro(void);
MACRO *getmacroptr(char *st);
PUBLIC void initmacro(void);
/*--------------------*
   INTERNAL FUNCTION
 *--------------------*/
/* 1.Macro  data structure management */
LOCAL void  addmacrogate(MACRO *m,MACROGATE *p);
LOCAL void  delmgate(MACRO *m);
LOCAL MACRO *newmacro(void);
LOCAL void  rmmacro(MACRO *m);
/* 2.Macro compilation                */
LOCAL void  makesymtable(MACRO *m);
LOCAL MACROSYM   *searchsym(char *st,MACROSYM symtab[],int symlen);
LOCAL int   scan1gate(MACRO *m,char *buff);
LOCAL void  scan_gate(MACRO *m);
LOCAL void  list1macro(MACRO *m);
/*  Share variable */
LOCAL char    linebuff[256];      /* Line input buffer */
LOCAL char    *argv[20];
LOCAL char    argvb[20][20];
LOCAL MACRO   *firstm=NULL,*lastm=NULL;
LOCAL int     macrocount=0;
/*-----------------------*
   MACRO DATA MANAGEMENT
 *-----------------------*/
MACRO *newmacro()
{
    MACRO *p;
    if ((p=malloc(sizeof(MACRO) )) ==NULL)
      { lapperr(MEMFAULT);  exit(MEMFAULT); }
    p->gfirst=p->glast=NULL;
    p->elmnum=p->xnodenum=p->inodenum=p->expand=0;
    return(p);
}
int addmacrolist(MACRO *p)
{
   p->next=NULL;
   if(firstm==NULL) firstm=p;
     else lastm->next=p;
   lastm=p;
   return(++macrocount);
```

```
}
void rm1macro(MACRO *m)
{
        delmgate(m);
        free(m->xsym);
        free(m->isym);
}
PUBLIC void freemacro(void)
{
   MACRO *p;
   int i;

   for(p=firstm;p !=NULL;p=p->next)
     rm1macro(p);
   macrocount=0;
}
PUBLIC MACRO *getmacroptr(char *st)
{
     MACRO *p;
     int i;

     for(p=firstm; p !=NULL;p=p->next)
       {
          if (!strcmp(st,p->name) ) return(p);
       }
      return(NULL); /* NOT FOUND */
}
/*-------------------------------------------------------------
   Init macro must be called once when software start
   or load new network
 *-------------------------------------------------------------*/
PUBLIC void  initmacro(void)
{
    firstm=lastm=NULL;
    macrocount=0;
}
/*-------------------------------*
    Internal macro gate routine
 *-------------------------------*/
void addmacrogate(MACRO *m,MACROGATE *p)
{
     p->next=NULL;
     if (m->gfirst==NULL)  m->gfirst=p;
       else  m->glast->next=p;
     m->glast=p;
}
void delmgate(MACRO *m)
{
    MACROGATE *p;

    for(p=m->gfirst;p !=NULL;p=p->next)
      free(p);
}
MACROGATE *newmgate(void)
{
   MACROGATE *p;
   if ((p=malloc(sizeof(MACROGATE))) ==NULL) {
     puts("Macro gate memory allocation error!");
    exit(MEMFAULT);
     }
```

```
    return(p);
}

/*-----------------*
   MACRO COMPILE
 *-----------------*/
void makesymtable(MACRO *m)
{
    int i;

    fetchstr(linebuff);
    m->xnodenum=strargv(linebuff,argv);
    printf("EXT: %s",linebuff);
    m->xsym=(MACROSYM *)calloc(m->xnodenum,sizeof(MACROSYM));
    for(i=0;i < m->xnodenum;i++)
       strcpy( m->xsym[i].str,argv[i]);

    fetchstr(linebuff);
    m->inodenum=strargv(linebuff,argv);
    printf("INT: %s",linebuff);
    m->isym=(MACROSYM *)calloc(m->inodenum,sizeof(MACROSYM));
    for(i=0;i < m->inodenum;i++)
       strcpy(m->isym[i].str,argv[i]);
#if  defined(DEBUG_MACRO)
  puts("SHOW SYMTABLE");
    for(i=0;i<m->xnodenum;i++)
         printf("[%02d] %s\n",i,m->xsym[i].str);
    for(i=0;i < m->inodenum;i++)
         printf("<%02d> %s\n",i,m->isym[i].str);
#endif
}

MACROSYM *searchsym(char *st,MACROSYM symtab[],int symlen)
{
     register i;

     for(i=0;i<symlen;i++)
       if (strcmp(symtab[i].str,st)==0) return(symtab+i);
     return(NULL);  /* return Null if not found */
}
int scan1gate(MACRO *m,char *buff)
{
    int  pin,i,index;
    MACROGATE  *p;
    MACROSYM   *entry;
    LOGICMODEL *model;
    char tbuff[10];

    strargv(buff,argv);
    if (strcmp(argv[0],"ENDM")==0) return(FALSE);
    /* Perform syntax check here */
    strtrunc(tbuff,argv[1],IDENLEN);
    if ( (model=getmodelptr(tbuff)) !=NULL)
      {  /* Syntax all ok. */
        p=newmgate();
        strtrunc(p->name,argv[0],IDENLEN);
        p->model=model;
        p->inum=model->inum;
        p->onum=model->onum;
        p->td=model->td;      /* Now use only default delay */
```

```
        for(index=2,pin=0;pin<p->inum;pin++)
         {
           if ( (entry=searchsym(argv[pin+index],m->isym,m->inodenum))==NULL)
            if ( (entry=searchsym(argv[pin+index],m->xsym,m->xnodenum))==NULL)
             { printf("INVALID INPUT NODE PIN:%d\n",pin);  entry=m->xsym; }
           p->ipin[pin]=entry;
         }
        for(index=p->inum+2,pin=0;pin<p->onum;pin++)
         {
           if ( (entry=searchsym(argv[pin+index],m->isym,m->inodenum))==NULL)
            if ( (entry=searchsym(argv[pin+index],m->xsym,m->xnodenum))==NULL)
             { printf("INVALID OUTPUT NODE PIN:%d\n",pin);  entry=m->xsym; }
           p->opin[pin]=entry;
         }
         addmacrogate(m,p);
       }
     else puts("INVALID MODEL REFERENCE IN MACRO COMPILATION!");
     return(TRUE);
}
void scan_gate(MACRO *m)
{
    do {
      fetchstr(linebuff);
      printf("%s",linebuff);
    } while (scan1gate(m,linebuff));
}
PUBLIC void editmacro(int margc,char *margv[])
{
      MACRO *mptr;
      register i;

      if( margc !=2) {  puts("MACRO SYNTAX ERROR !");  return;  }
      for(i=0;i<20;i++)  argv[i]=argvb[i];
      mptr=newmacro();
      strtrunc(mptr->name,margv[0],IDENLEN);
      makesymtable(mptr);
      scan_gate(mptr);
      addmacrolist(mptr);  /* Add new macro to MACRO link list */
}
/*------  END MACRO EDITOR FUNCTION ------*/
/*-------------------------*
   MACRO LISTING FUNCTION
 *-------------------------*/
void list1macro(MACRO *m)
{
   int i;
   MACROGATE *p;

   printf("MACRO: %*s\n",IDENLEN,m->name);
   printf("EXT: ");
   for(i=0;i<m->xnodenum;i++)
     printf("%6s",m->xsym[i].str);
   printf("\nINT: ");
   for(i=0;i<m->inodenum;i++)
     printf("%6s",m->isym[i].str);
   printf("\n");
   for(p=m->gfirst;p !=NULL;p=p->next)
    {
       printf("%6s%6s%6d",p->name,p->model->name,p->td);
       for(i=0;i<p->inum;i++) printf("%6s",p->ipin[i]->str);
```

```
        for(i=0;i<p->onum;i++) printf("%6s",p->opin[i]->str);
        printf("\n");
     }
    printf("END MACRO: %*s\n",IDENLEN,m->name);
}
PUBLIC void listmacro(void)
{
    MACRO *p;

    for(p=firstm;p !=NULL;p=p->next) list1macro(p);
    printf("Total macro defined:%5d \n",macrocount);
}
/*-------------------*
    MACRO EXPANSION
 *-------------------*/
PUBLIC void expandmacro(int argc,char *argv[],MACRO *m)
{
     register i,pin;
     LOGICNODE *p;
     LOGICELEMENT *gate;
     MACROGATE *g;

     if (argc != (m->xnodenum+2) ) /* Check for correct arg */
       {  lapperr(SYNTAXERR); return; }
     /* Fill Internal node link */
     for(i=0;i<m->inodenum;i++)
      {
         m->isym[i].node=p=makenewnode("$");
         p->type=INTERN;
         addnode(p);
      }
     /* Fill xtern link table */
     for(i=0;i<m->xnodenum;i++)
       {
           m->xsym[i].node=p=getnodeptr(argv[i+2]);
           p->type=XTERN;
       }
     /* Scan all element */
      for(g=m->gfirst;g !=NULL;g=g->next)
      {
          gate=makenewgate("#");
          gate->type=INTERN;
          gate->model=g->model;
          gate->td=g->td;
          gate->inum=g->inum;
          gate->onum=g->onum;
          gate->ps=LOW;
          for(pin=0;pin<g->inum;pin++)
            gate->in[pin]=g->ipin[pin]->node;
          for(pin=0;pin<g->onum;pin++)
            gate->out[pin]=g->opin[pin]->node;
          addelm(gate);
       }
}
```

```
/*
 *   MODULE: LAPDISPLAY
 *   AUTHOR: P.UTHAYOPAS
 *   DATE:
 *          This is display section for lap software
 */
#include   <stdio.h>
#include   <dos.h>
#include   <ctype.h>
#include   "lap.h"
#include   "lapcmd.h"
#include   "lapdata.h"
#include   "laputil.h"
#include   "hgraphic.h"

IMPORT   const int   usrtime;    /* Real sim time now from lapsim */

#define  XMIN           50        /* Minimum display area       */
#define  XMAX           640       /* Maximum display area       */
#define  XST            140       /* x end of label block       */
#define  XTSTR          140       /* START X OF TIMING DISPLAY  */
#define  XTEND          640       /* END X OF TIMING DISPLAY    */
#define  MAXTSCALE      500       /* maximum display point      */
#define  GRIDHIGH        19
#define  GRIDLOW        257
#define  MIDDLECOL       42
#define  LABELLEFT       8
#define  STATLINMIN      36
#define  STATLINMAX      42
#define  statline(n)     (n+STATLINMIN)  /* ROW OF STAT LINE n */
#define  labelbase(n)    (16*n+16)       /* BASE Y CO-ORDINATE OF LABEL */
/* Level of signal graph */
#define  signal0(n)      (16*n+14)
#define  HLEVEL           8
#define  ZLEVEL           4
#define  baseline(n)     (n*8)           /* base Y of line n */

LOCAL void  heading(st) /* Display heading field */
char *st;
{     int stcol;
      stcol=MIDDLECOL-(strlen(st)/2);
      box(XMIN,baseline(2)-12,XMAX,baseline(2)+2);
      gotogxy(stcol,2); gputs(st);
}
LOCAL void  label(n,st) /* Display label #n <1-15>  */
int n;
char *st;
{
       if ((n<=15)&&(n>0) ) {
        writestr(LABELLEFT,2*n+2,st); }
}
LOCAL void dispframe()
{
  register i;
  int yh,yl;

  yh=18;    yl=258;
  box(XMIN,yh,XMAX,yl);
  line(XST,yh,XST,yl);
  for(i=1;i<=15;i++)
```

```
    {
        yh=labelbase(i)+2;  line(XMIN,yh,XST,yh);
    }
}
LOCAL void dpstatbox()
{
     box(XMIN,baseline(STATLINMIN)-5,XMAX,baseline(STATLINMAX)+5);
}
LOCAL void  dpstatline(n,col,st)
int n;
int col;
char *st;
{
   writestr(LABELLEFT+col-1,statline(n),st);
}
LOCAL void dptimescale(scale)
int scale;
{
    int x,y,inc;

    gotogxy(LABELLEFT,34);  gputs("TIME");
    y=baseline(34);
    inc=scale*10;
    line(XTSTR,y-5,XTEND,y-5);
    for(x=0;x<=MAXTSCALE;x+= inc)
      line(XTSTR+x,y-3,XTSTR+x,y-7);
}
/*---------------------------*
  Time grid control routine
 *---------------------------*/
LOCAL void initmovgrid();
LOCAL void drawgrid();
LOCAL void gridright();
LOCAL void gridleft();
LOCAL void movgrid();

LOCAL BOOLEAN gridon=FALSE;
LOCAL int  gridxst;
LOCAL int  gridx;
LOCAL int  mgridstep;

void initmovgrid()
{
     gridon=FALSE;
     gridx=0;   /* Grid first position on left most */
     mgridstep=1;
}

void drawgrid(step,scale) /* Fix grid line */
int step;
int scale;
{
    int x,inc;

    if ( ! gridon)
    {
    inc=step*scale;
    drawmode(PENXOR);
    for(x=0;x<MAXTSCALE;x+=inc) {
      vdash(XTSTR+x,GRIDHIGH,GRIDLOW,3);  }
```

```
    drawmode(PENDOWN);
    }
}
/* Moving grid routine */
void gridleft(scale)
int scale;
{
 char buff[5];
 int inc;
 if (gridon)
 {
  drawmode(PENXOR);
  inc=mgridstep*scale;
  vdash(XTSTR+gridx,GRIDHIGH,GRIDLOW,1); /* erase old grid */
  gridx=( ( (gridx - inc) < 0 ) ? gridx : gridx-inc);
  vdash(XTSTR+gridx,GRIDHIGH,GRIDLOW,1); /* draw new grid */
  drawmode(PENDOWN);
  sprintf(buff,"%3d",gridxst+ gridx/scale);
  dpstatline(4,8,buff);
 }
}
void gridright(scale)
int scale;
{
  char buff[5];
  int inc;
 if (gridon)
 {
  drawmode(PENXOR);
  vdash(XTSTR+gridx,GRIDHIGH,GRIDLOW,1); /* erase old grid */
  inc=mgridstep*scale;
  gridx=( ((gridx+ inc)>MAXTSCALE) ? gridx : gridx+inc);
  vdash(XTSTR+gridx,GRIDHIGH,GRIDLOW,1); /* draw new grid */
  drawmode(PENDOWN);
  sprintf(buff,"%3d",gridxst+ gridx/scale);
  dpstatline(4,8,buff);
 }
}
void gridfast()
{
  char buff[5];
  mgridstep=( (++mgridstep >40) ? 1 : mgridstep);
  sprintf(buff,"%2d",mgridstep);
  dpstatline(4,22,buff);
}
void gridslow()
{
  char buff[5];
  mgridstep=( (--mgridstep < 1) ? 40 : mgridstep);
  sprintf(buff,"%2d",mgridstep);
  dpstatline(4,22,buff);
}
void movgrid()
{
    int yh,yl;
    yh=18;    yl=258;
    drawmode(PENXOR);
    if (gridon)  gridon=FALSE;
       else gridon=TRUE;
    vdash(XTSTR+gridx,yh,yl,1);
```

```
    drawmode(PENDOWN);
}
/*------------------------*
   Signal display routine
 *------------------------*/
LOCAL void dplow(xs,ys,scale)
int xs;
int ys;
int scale;
{
  line(xs,ys,xs+scale,ys);
}
LOCAL void dphigh(xs,ys,scale)
int xs;
int ys;
int scale;
{
  line(xs,ys-HLEVEL,xs+scale,ys-HLEVEL);
}
LOCAL void dpzstate(xs,ys,scale)
int xs;
int ys;
int scale;
{
  line(xs,ys-ZLEVEL,xs+scale,ys-ZLEVEL);
  line(xs,ys-ZLEVEL-1,xs+scale,ys-ZLEVEL-1);
}
LOCAL void dpunknown(xs,ys,scale)
int xs;
int ys;
int scale;
{
    line(xs,ys-HLEVEL,xs+scale,ys-HLEVEL);
    line(xs,ys,xs+scale,ys);
    line(xs,ys,xs+scale,ys-HLEVEL);
    line(xs,ys-HLEVEL,xs+scale,ys);
}
LOCAL void dpbusfault(xs,ys,scale)
int xs;
int ys;
int scale;
{
   line(xs,ys-HLEVEL,xs+scale,ys-HLEVEL);
   line(xs,ys,xs+scale,ys);
   line(xs,ys,xs+scale,ys-HLEVEL);
}

LOCAL void dp1signal(n,data,scale)
int n;
LOGICSTATE *data;
int scale;
{
       register t;
       LOGICSTATE  logic,prelogic;
       int   xplot,yplot,maxplot;
       static int spike_mask=0xbf;

       prelogic=LOW;
       maxplot=MAXDPSTEP/scale; /* Maximum x plot */
       for(t=0;t < maxplot ;t++)
```

```
        {
          xplot=scale*t + XTSTR;
          yplot=signal0(n);
          logic=( ((data[t] & BUS_CONTENSION) !=0) ?  BUS_CONTENSION : data[t]);
          logic &=spike_mask;  /* suppress spike display  */
          switch( logic )
           {
             case LOW    :
                       dplow(xplot,yplot,scale);
                       break;
             case HIGH   :
                       dphigh(xplot,yplot,scale);
                       break;
             case ZSTATE :
                       dpzstate(xplot,yplot,scale);
                       break;
             case UNKNOWN :
                       dpunknown(xplot,yplot,scale);
                       break;
             case BUS_CONTENSION :
                       dpbusfault(xplot,yplot,scale);
                       break;
           }
          if (logic != prelogic )
             line(xplot,yplot,xplot,yplot-HLEVEL);
          prelogic=logic;
        }
}

LOCAL  void showsig(cmdptr)
CMD_DISPLAY *cmdptr;
{
     int i,t,n,range;
     static char buff[100];
     IMPORT int gridx,gridxst;

     hirespage(1);
     heading("SIMULATION RESULT FROM LAP 1.0");
     dispframe();
     dptimescale(cmdptr->scale);
     dpstatbox();
     range=(MAXDPSTEP/cmdptr->scale)+cmdptr->rtime+cmdptr->timestart;
     gridxst=cmdptr->rtime+cmdptr->timestart;
     sprintf(buff,"TIME:%05d TO %05d SCALE:%02d GRID:%02d MRT",
               gridxst,range,cmdptr->scale,cmdptr->gridstep);
     dpstatline(2,1,buff);
     sprintf(buff,"OFFSET:%3d MRT SPEED:%2d STEP",gridxst,mgridstep);
     dpstatline(4,1,buff);
     sprintf(buff,"F2-HARDCOPY  F3-GRID ON/OFF  F4-MOVING GRID ESC-EXIT");
     dpstatline(6,1,buff);
     for(i=0;i< cmdptr->nodisp;i++) {
       n=i+1;
       sprintf(buff,"%s",cmdptr->nodename[i]);
       label(n,buff);
       dp1signal(n,(cmdptr->simdata[i] + cmdptr->timestart),cmdptr->scale);
      }
}

LOCAL  void showtiming(cmdptr)
CMD_DISPLAY *cmdptr;
```

```
{
     int timelimit;
     int key;

     drawmode(PENDOWN);
     initmovgrid();
    /* Adjust display start time  */
    timelimit=MAXTIME-(MAXDPSTEP/cmdptr->scale);
    cmdptr->timestart=(  cmdptr->timestart >timelimit
                       ? timelimit
                       : cmdptr->timestart);
    cmdptr->rtime=( usrtime >MAXTIME ? usrtime-MAXTIME : 0);
     showsig(cmdptr);
     if (cmdptr->waittime!=0)
        { sleep(cmdptr->waittime);
          text();
          return; }
     while( (key=getkey()) !=ESC ) /* wait for ESC key */
     {
       switch(key)
        {
          case F2    :  hardcopy(1);
                        break;
          case F3    :  drawgrid(cmdptr->gridstep,cmdptr->scale);
                        break;
          case F4    :  movgrid();
                        break;
          case LEFTKEY  : gridleft(cmdptr->scale);
                          break;
          case RIGHTKEY : gridright(cmdptr->scale);
                          break;
          case '+'      : gridfast();
                          break;
          case '-'      : gridslow();
                          break;
        }
      }
     text();
}  /* end of display */

/*-------------------------
   Set display parameter
 *-------------------------*/
LOCAL  void setdpparam(cmdptr)
CMD_DISPLAY *cmdptr;
{
    LOGICNODE *p;
    int num,timelimit;

    puts("** Display parameter setting **");

    /* Reading display scale */
    do {
    printf("Display scale[%02d]>",cmdptr->scale);
    num=getint();
    } while ( (num > MAXDPSCALE) ||(num < 0) );
    if (num ==0) cmdptr->scale=( cmdptr->scale >0 ? cmdptr->scale : 1);
       else cmdptr->scale=num;

    /* Read display starting time */
```

```
    do {
    printf("Display start at step <0-%d>[%05d]>",MAXTIME,cmdptr->timestart);
    num=getint();
    } while ( (num > MAXTIME) ||(num < 0) );
    cmdptr->timestart=num;
    /* reading display grid step width */
    do {
    printf("Display grid every[%03d]>",cmdptr->gridstep);
    num=getint();
    } while ( (num > MAXGRIDSTEP) ||(num < 0) );
    if (num ==0) cmdptr->gridstep=( cmdptr->gridstep>0 ? cmdptr->gridstep : 1);
       else cmdptr->gridstep=num;

}
LOCAL  void setdpnode(cmdptr)
CMD_DISPLAY *cmdptr;
{
    LOGICNODE *p;
    int num,i;
    static char buff[20];

    do {
    printf("NO. of node to display (less than 15):");
    num=getint();
    } while ( (num > MAX_DISPLAY_NODE) ||(num < 0) );
    for(i=0;i < num;i++)
     {
       do {
       printf("<%2d> NAME:",i+1); gets(buff);
       strupr(buff);
       if ((p=oldnode(buff))==NULL) then
         printf("Invalid node name or name not found!\n");
       } while ( p ==NULL);
       cmdptr->simdata[i]=p->outstate;
       cmdptr->nodename[i]=p->name;
     }
     cmdptr->nodisp=num;
}

LOCAL void   showsigtab(p)
CMD_DISPLAY *p;
{
     int i,col,limit;

     printf("\t\t*** DISPLAY SIMULATION RESULT TABLE ***\n");
     limit=( (MAXTIME - p->timestart) < 70 ? MAXTIME - p->timestart : 70 );
     printf("TIME:%5d TO %5d\n\n",p->timestart,p->timestart+limit);
     for(col=0;col < p->nodisp;col++)
       {
         printf("%6s:",p->nodename[col]);
         for(i=0;i< limit ;i ++)
           {
            printf("%c",logictoc(*(p->simdata[col] + p->timestart +i)) );
           }
         printf("\n");
       }
    printf("\n\n");
}

LOCAL void init_display(p)
```

```
CMD_DISPLAY *p;
{
     register i;

     p->cmd=SETUP;
     p->nodisp=0;  /* No data to display */
     p->rtime=0;
     p->scale=1;
     p->gridstep=20;
}
/*
 *   Main section of display module
 */
PUBLIC void dspmodule(p)
CMD_DISPLAY *p;
{
  switch(p->cmd)
  {
     case  INITDP       :   init_display(p);
                            break;
     case  SETUP        :   setdpparam(p);
                            break;
     case  NODESEL      :   setdpnode(p);
                            break;
     case  TABLE        :   showsigtab(p);
                            break;
#ifdef   IBMPC
     /* Timing display can only used in IBM with Hercules card */
     case  TIMING       :   showtiming(p);
                            break;
#endif
  }
}
```

```
#include   <stdio.h>
#include   <fcntl.h>
#include   <ctype.h>
#include   <string.h>
#include   <dir.h>
#include   <stat.h>
#include   <dos.h>
#include   <bios.h>
#include   <io.h>
#include   <errno.h>
#include   <alloc.h>
#include   "lap.h"
#include   "laputil.h"

/* Uses the BIOS to read the next keyboard character */
int getkey(void)
{
 int key, lo, hi;

 key = bioskey(0);
 lo = key & 0X00FF;
 hi = (key & 0XFF00) >> 8;
 return((lo == 0) ? hi + 256 : lo);
} /* getkey */

void waitkey()
{
  printf("\nWAITING...");
  getkey();
}

/*-------------------------------------------------
      NAME: findcmdcode(cmd,cmdtab,length)
      USAGE: convert command string to code
      char     *cmdstr;          Command string
      CMDTABLE *cmdtab;          Command string table
      int  length;       length of code table
 *-------------------------------------------------*/
int  findcode(char *cmd,CMDTABLE  *cmdtab,int length)
{
   register i;
   for(i=0; i< length;i++ )
        if ( !strcmp(cmd,(cmdtab+i)->str) ) return( (cmdtab+i)->code);
   /* not found  */
   return(NULL);
}

/*-----------------------------------
   DISPLAY PROMPT AND GET DATA INPUT
 *-----------------------------------*/
PUBLIC char     *getcmdln(char *prompt,char *buff)
{
   char *p;
   do
    {  printf(prompt);
       gets(buff);
    } while  (strlen(buff)==0);
   /* CONVERT CONTROL CODE TO SPACE */
   for(p=buff;*p;p++) if ( iscntrl(*p) ) *p=0x20;
    strupr(buff);  /* Convert string to uppercase */
```

```
    return(buff);
}

/*-------------------------------------------------------------*
  NAME:  int strarg(char *argv[]);
  USAGE:
        SEPERATE INPUT STRING INTO PART USING WHITE SPACE
        AS SEPERATOR
    Parameter:
        argv =array of pointer to buffer (same as argv in C)
    Return:  parameter count
 *-------------------------------------------------------------*/
PUBLIC int strargv(char *ln,char *argv[])
{
    int argc;
    char *p;

    /* Change all  control code to blank */

    for(argc=0; *ln ;)
       {
         while( isspace( *ln) ) ++ln; /* SKIP WHITE SPACE */
         if (*ln==0) continue;  /* check if space only in input buffer */
         for(p=argv[argc++]; ! (isspace(*ln) || (*ln==0) ) ;)
           *(p++) = *(ln++);
         *p=0;
         }
     return(argc);
}

/*-------------------------------------------------------------*
    NAME:prmlist(argc,argv)
    USAGE: list parameter accept from getcmd()
    PARAMETER:
       unsigned argc=argument count
       char *argv[] =pointer to argument value
    RETURN: none
 *-------------------------------------------------------------*/
PUBLIC void prmlist(int argc,char *argv[])
{
   int i;
   printf("Number of parameter: %d\n",argc);
   for (i=0;i< argc;i++)
     printf("Parameter [%2d] : %s\n",i,argv[i]);
}

PUBLIC int getint(void) /*  return integer value read from user */
{
  static char buffer[20];
  static int x;

  gets(buffer);
  x=atoi(buffer);
  return(x);
}
/* Truncate string to n character */
PUBLIC char *strtrunc(char *st1,char *st2,int n)
{
      strncpy(st1,st2,n);  /* Truncate only first n char */
      st1[n]=NULL;         /* NULL terminatre for  buffer */
```

```
    return(st1);
}

/* Convert input char to logicstate */
LOGICSTATE tologic(char c)
{
    switch(c)
     {
       case  '1' :
       case  'H' :   return(HIGH);
       case  '0' :
       case  'L' :   return(LOW);
       case  'Z' :   return(ZSTATE);
       case  'X' :   return(UNKNOWN);
       default   :   return(UNKNOWN);
     }
}
char  logictoc(LOGICSTATE s)
{
    static char stab[]={'L','H','X','Z'};
    return(stab[s]);
}
/*
 *    Standard error message string
 *    imitate perr\90 function
 */
PUBLIC   int laperrnum;   /* internal error code in lap */
PUBLIC   int lapmaxerr=2;   /* maximum error code         */
PUBLIC   char *laperrstr[]={
           "Syntax error!",
           "Invalid command",
           "Memory allocation fault! abort LAP1.0"
           };

/*-------------------------------------------------*
   LAPERRMSG  - return char * to error message
 *-------------------------------------------------*/
PUBLIC char *laperrmsg(int errnum)
{
    return(laperrstr[errnum]);
}

PUBLIC void lapperr(int num)
{
  printf("%s\n",laperrstr[num]);
}

/*---------------------------------*
   S Y S T E M   I N T E R F A C E
 *---------------------------------*/
/*
      NAME: dir( char *pathname)
      display directory specify "pathname"
*/
int dir(char *st)
{
  struct ffblk ffblk;
  int done,count,colc;
  char *name,*ext;
  unsigned long dfree;
```

```
  static char *blank="    ";
  printf("DIRECTORY of %s\n\n",st);
  count=0;
  colc=0;
  done=findfirst(st,&ffblk,0);
  while(!done) {
   count++;
   if ( colc > 4 ) then { printf("\n"); colc=1; }
     else colc++;
   name=ffblk.ff_name;
   if ( (ext=strchr(name,'.') ) ==NULL)  ext=blank;
     else {  *ext=0; ++ext; }
   printf("  %-8s.%-3s ",name,ext);
   done=findnext(&ffblk);
   }
   dfree=diskfree(0); /* Get current drive free space */
   printf("\n\t%4d FILE(S) %10ld Bytes available on disk\n",count,dfree);
   return(count);
}
unsigned long diskfree(int drv)
{
  unsigned long bperc;  /* byte per cluster */
  struct dfree dfbuff,*p;

  p=&dfbuff;
  getdfree(drv,p);
  bperc=p->df_bsec * p->df_sclus;
  return(p->df_avail * bperc);
}

/*   MEMAVAIL()  - Report memory size available */
unsigned long memavail(void)
{
  return( coreleft() );
}
void delfile(char *st)
{
    int retcode;

    retcode=unlink(st);
    if (retcode==0) return;
    switch(errno)
     {
        case ENOENT  :
                puts("PATH OR FILE NOT FOUND! TRY FULL PATH NAME");
                break;
        case EACCES :
                puts("ACCESS DENIE FOR THIS NAMED FILE!");
                break;
     }
    errno=0;  /* reset errno */
     return;
}
PUBLIC void typefile(char *st)
{
   FILE *fp;
   char c;

   if ((fp=fopen(st,"r"))==NULL) then
```

```
    {  puts("File not found in current directory!"); }
    else
     {
        while( (c=fgetc(fp)) !=EOF)
          putchar(c);
        fclose(fp);
     }
   printf("\n");
}
PUBLIC void copyfile(char *source,char *target)
{
  int src,dest;   /* Source and destination file handle */
  int saccess,daccess,dpermiss; /* Access code of file */
  static char buff[512];
  int len;
  extern int sys_nerr;
  extern char *sys_errlist[];

  /* Construct source file access key */
  saccess=O_RDONLY | O_BINARY;
  if ((src =open(source,saccess) ) ==-1)
    {
       if (errno < sys_nerr)
         printf("%s !\n" ,sys_errlist[errno]);
        errno=0;
       return;
    }
  /* Construct destination file access key */
  daccess=O_CREAT | O_TRUNC | O_BINARY | O_WRONLY;
  dpermiss= S_IREAD | S_IWRITE;
  if ( (dest=open(target,daccess,dpermiss)) == -1)
    {
       if (errno < sys_nerr)
         printf("%s !\n" ,sys_errlist[errno]);
        errno=0;
       return;
    }
  while ( (len=read(src,buff,512)) > 0)
    write(dest,buff,len);
  close(src);
  close(dest);
}
```

ประวัติผู้เขียน

นายภุชงค์ อุทโยภาศ เกิดเมื่อวันที่ 26 มิถุนายน พ.ศ.2507 ที่อำเภอบางกอกน้อย กรุงเทพมหานคร สำเร็จการศึกษาขั้นปริญญาตรีจาก ภาควิชาวิศวกรรมไฟฟ้า คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ในปีการศึกษา 2527 ปัจจุบัน ทำงานในตำแหน่งวิศวกรออกแบบ แผนกซอฟแวร์และออกแบบ บริษัทไฟฟ้าฟิลิปส์แห่งประเทศไทย