Extending X for Double-Buffering, Multi-Buffering, and Stereo

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> " (*"
I F I
> G(
3 B + '(" J
J ="" (" #
K &, " I
&
G(
% (G(B < +
E(" G(B < + 3
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Warning

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Chapter 1. Introduction

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" 9

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Chapter 2. Goals

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Chapter 3. Image Buffers

B + + * " ("! " CreateWindow '("9

```
CreateWindow
     parent          : WINDOW
     w_id            : WINDOW
     depth           : CARD8
     visual          : VISUALID or CopyFromParent
     x, y            : INT16
     width, height   : INT16
     border_width    : INT16
     value_mask      : BITMASK
     value_list      : LISTofVALUE
```

.! '(" *" " + + "" (" (" +!*!
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"* 7 *" (* " +"! + +

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+ ", " "! (

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(>%

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H 0 (, " " > *- (
"! + + "! "! * * " " " " "! * " " (
((> *- " + "
("! 0 (, " "

Chapter 4. New Requests

.! + '(" CreateImageBuffers * " ((
* " "! +"! + +9

```
CreateImageBuffers
     w_id           : WINDOW
     buffers        : LISTofBUFFER
     update_action  : {Undefined,Background,Untouched,Copied}
     update_hint    : {Frequent,Intermittent,Static}
     =>
     number_buffers : CARD16

     (Errors: Window, IDChoice, Value)
```

; (+ * " +"! *!>% .! " (
"! " " (PLQ "! 0" (P Q & *! (+
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+"! "! + + *- (4 *- ("! (* " "
(7 H 0 , " + " *! "!
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"! ("!, *- "

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" (*) *" 9

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* " 4 (" " *! " "! ! "7) ! "
9

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0 * *- "! " (" * ("

" " * .! (+ " *! " .
* " * " +! , "! ("!
"

. ("! + '(" * (9

```
DisplayImageBuffers
     buffers         : LISTofBUFFER
     min_delay       : CARD16
     max_delay       : CARD16

     (Errors: Buffer, Match)
```

.! (" + * (" (
"! (" *" (" CreateImageBuffers " +

= " (* " + "! , " * " *! "!
"! + + " " 4 9 +! * + "! (7
="" " " (" ((" ("! + +

4 Match7 * ", " "! ("!" ((
* " "

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"!" (> "! " * "! (" *" ')
4 * 7+ !, *" "! * " " "! (
.! "* + " *" " (** (0*(" , +!
"! (, + +

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+"! *" "! (" *" +!"! "! (, ,
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" ("!, *- " 4 "! * (" *"
+ 7 "! * " " " " (+ * (

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& (! + *" " ″ ″ " , "!"
" *! H " " "! , * (" , "! *("
0 & (! LL *" "! , !(+ " " " 8 L
* * "! " " "! + + + (" = & (! H
*" + " *

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" * , (& (! H

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mageBuffers '(" *! (" (+ + " , ""
"! , .! , 0*(" "! DisplayImageBuffers '("
(" "! " " 4 '(("! '(" " * (" "! "
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*(" , " (" " <! , " +"! "
* *(* "! 0" (" ! " "! * *(* "*
"! "! * "*

. 0 *" * *" ((" "! + + *- (
"! + '("* (9

```
ClearImageBufferArea
     buffer          : BUFFER
     x, y            : INT16
     w, h            : CARD16
     exposures       : BOOL

     (Errors: Buffer, Value)
```

- "! ClearArea '(" ! ", " "! + +6 *
"! (" * "! *" > ″ # H " * + "! "! *(
"+ + + "! (> # # H " * + "! "! *("+ +
! !" (! > "! + + ! *- (" "! *" "
+ "! - (*" + ! (+ + +
!+# > "! + + ! *- (, "! * " " "! ("
*! > "! * "("! 0 (, "
" "! *" "! " "! , "
*- "

.! ((* " CreateImageBuffers '(" *
" + "! "! + '("9

```
DestroyImageBuffers
     w_id          : WINDOW

     (Error: Window)
```

.! * " "+ "! (>%6 "! * (
" = (" *" * " > "! + +
" (" ("! '("

Chapter 5. Attributes

.! + "" (" + * " +"! *!+ +"!" (" (9

```
     displayed_buffer : CARD16
     update_action    : {Undefined,Background,Untouched,Copied}
     update_hint      : {Frequent,Intermittent,Static}
     window_mode      : {Mono,Stereo}
     buffers          : LISTofBUFFER
```

*! (" " "! "! *(" (4
" + + "! + "! 0 "! " (R "! 0 "! !" (
S 7 ″ ″(& * " +!"! "! + + %
.! >% *! (* " +"!"! + + * "! "
.! , "" (" * '(+"!"! + '("9

```
GetMultiBufferAttributes
     w_id             : WINDOW
     =>
     displayed_buffer : CARD16
     update_action    : {Undefined,Background,Untouched,Copied}
     update_hint      : {Frequent,Intermittent,Static}
     window_mode      : {Mono,Stereo}
     buffers          : LISTofBUFFER

     (Errors: Window, Access, Value)
```

> "! + + " (" (Access + " .! (
" ("" (" "!"* 0 *" " (# "! "! !,
* * '(" " " "! "" (" * " '(" , " + (
"(0 9

```
SetMultiBufferAttributes
     w_id             : WINDOW
     value_mask       : BITMASK
     value_list       : LISTofVALUE

     (Errors: Window, Match, Value)
```

> "! + + " (" (Match + " .! +
"" (" " *! ((" (+ +9

```
     window           : WINDOW
     event_mask       : SETofEVENT
     index            : CARD16
     side             : {Mono,Left,Right}
```

″ ″ * " "! + +"! (* " +"! - (&) *
+!*! , " , " " (+ " *-" "! * ", "! * "
(>% 4 " , " *" 7 "! " " 4L 7 "!

```
(            * "  +! "!  "!  (       * "  + "! "!   "       !"
     "   +  +     "   +  +  "!  ""  (" +     " "
.!   ""  ("  *   '(   + "! "!    +   '( "9


GetBufferAttributes
     buffer           : BUFFER
     =>
     window            : WINDOW
     event_mask        : SETofEVENT
     index             : CARD16
     side              : {Mono,Left,Right}

     (Errors: Buffer, Value)

.!    (    ""  (" "! " *    0  * "   "                      - (& )       .!     , "
"! "   ,            Expose   "!  +      ClobberNotify     UpdateNotify , "4
&, "   *"     +7 =          Value    +       "      , "  "   *"
   (      *       , "  -  "! "! !,    *  *  '( " "  "
"!  ""  ("      *  "  '( "    ,   "    +   ("(  0    9


SetBufferAttributes
     buffer           : BUFFER
     value_mask       : BITMASK
     value_list       : LISTofVALUE

     (Errors: Buffer, Value)

  "   + " " '(  "!   ,   ("   * ( "  (      "   *    "
    *      .!    +   '( "  "(        "      "  "! "
+ (    "  -        *         *! *      (       "
  "!    '(   9


GetBufferInfo
     root             : WINDOW
     =>
     info             : LISTofSCREEN_INFO

<!     SCREEN_INFO     BUFFER_INFO       9


     SCREEN_INFO      : [ normal_info : LISTofBUFFER_INFO,
                          stereo_info : LISTofBUFFER_INFO ]

     BUFFER_INFO      : [ visual       : VISUALID,
                          max_buffers : CARD16,
                          depth        : CARD8 ]

>   "        ( "  (         4   7 +  +    "(     "!
  & (          " .!        (          " * "       "    (" "   +  +  >
"!      (          "     "  "   +  +     " (  "    "!  *    >
& (            H   "!   0 (  (      (      "!   "!   , (
( *"    "!   H   "! *  "  +  +   *(   "       " "
```

.! + '(" "("! 1 , ("! 0"
9

```
GetBufferVersion
     =>
     major_number    : CARD8
     minor_number    : CARD8
```

.! , (* !"*! * ("(, "! " *
* > "! 1 , +(* " * " *!
"! , +(* " (+ * " *! G
*! "! 1 , + "! , +

Chapter 6. Events

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(" (+ + E " "! , " 4 9 ConfigureNotify7 +
" "! + + " *! (.! , " + "(+ +
>%

Expose , " + " "!"! + + (*" <!
"! , " " ("! , " "(*"(+ (("
(>% "(" + +>% " +! * "! , "
+ - + +!"! >% "(, " "(*"(+ + (
* "! "(>% " "! "(+! "! + + (
+ * "

GraphicsExposure NoExposure " (+!", >% *
"! !* " > + + >% * "! , " + * " "!
+ + >% > (>% * "! , "+ * " "! (>%

> " " , + + , (" (+ +
*(" (" " , + "" * (+ " . +
* " + " "! ("! "(" " " + ("
" "! (+ " "! + , " 9

ClobberNotify
  buffer : BUFFER
  state : {Unclobbered,PartiallyClobbered,FullyClobbered}

.! ClobberNotify , " " " * " *" + , ! (
<! ("!"+ (" * * (* , "
+"! *′ " <! ("!"+ (* *
" * , "+"! !+ " <! ("!"
+ (* " * * (* , "+"! .
!+ "

ClobberNotify , " , (" Expose , "
"!" ((" " " '("!" ClobberNotify , " (
" Expose , " (

.! ClobberNotify , " +"! *"" VisibilityNotify , "
" * "

> (" (+ (>; "+ , "!
, "! "! >; +(- " - + +! ("!"
+ , (! ((" "! *"
DisplayImageBuffers '(" .! + "! >; " (("(
(* , . (" "! "! + , "
9

UpdateNotify
  buffer : BUFFER

.! UpdateNotify , " " " * " *" * , ! (
<! , (* 4 " (" *" "
DisplayImageBuffers '("7 UpdateNotify , " "

Chapter 7. Errors

.! + " ! " (""! 0" 9

Buffer

=, (GA & (" " GA &

Double-Buffering Normal Windows

.! + (* " (" " !+" * " (
(9

```
/*
 * Create a normal window
 */
CreateWindow( W, ... )

/*
 * Create two image buffers.  Assume after display, buffer
 * contents become "undefined".  Assume we will "frequently"
 * update the display.  Abort if we don't get two buffers,
 */
n = CreateImageBuffers( W, [B0,B1], Undefined, Frequent )
if (n != 2) <abort>

/*
 * Map window to the screen
 */
MapWindow( W )

/*
 * Draw images using alternate buffers, display every
 * 1/10 of a second.  Note we draw B1 first so it will
 * "pop" on the screen
 */
while animating
{
     <draw picture using B1>
     DisplayImageBuffers( [B1], 100, 0 )

     <draw picture using B0>
     DisplayImageBuffers( [B0], 100, 0 )
}

/*
 * Strip image buffers and leave window with
 * contents of last displayed image buffer.
 */
DestroyImageBuffers( W )
```

Multi-Buffering Normal Windows

E(" ((" "! '(" .! + (
 * " (" " ! + " * " (" (* *
"! (! "! " (" , 9

```
/*
 * Create a normal window
 */
CreateWindow( W, ... )

/*
 * Create 'N' image buffers.  Assume after display, buffer
 * contents are "untouched".  Assume we will "frequently"
 * update the display.  Abort if we don't get all the buffers.
 */
n = CreateImageBuffers( W, [B0,B1,...,B(N-1)], Untouched, Frequent )
if (n != N) <abort>

/*
 * Map window to screen
 */
MapWindow( W )

/*
 * Draw each frame of movie one per buffer
 */
foreach frame
     <draw frame using B(i)>

/*
 * Cycle through frames, one frame every 1/10 of a second.
 */
while animating
{
     foreach frame
          DisplayImageBuffers( [B(i)], 100, 0 )
}
```

Stereo Windows

/ " " + + (" , " " " =
 , * " * H ! + "! " + " !" "
" " " .! " *" * , + "! "!
 * , + .! ! " *"(! ("
 ! + " "! * " " "! *"(* " % (
 (" (! (+! "! "!
 "

. *! , "! 0" " + + (" "
+ + 1(" - + + 0* " "! (

" (!" (. * " " + + * " -
"! + '("9

```
CreateStereoWindow
     parent          : WINDOW
     w_id            : WINDOW
     left, right     : BUFFER
     depth           : CARD8
     visual          : VISUALID or CopyFromParent
     x, y            : INT16
     width, height   : INT16
     border_width    : INT16
     value_mask      : BITMASK
     value_list      : LISTofVALUE

     (Errors: Alloc, Color, Cursor, Match,
              Pixmap, Value, Window)
```

.! '(" " "! CreateWindow '(" 1(""+ +
" 9 # " " " "!" * " (! +!"!
+ " " **("! " !" <! "
*(!, " *! , "! ("+ (>%6 + * " "
(" ((("! " !" * " " .! >%6
+ " 4 7 "! " !" ("!" *("
!

- + + "! + +>% (+! , + + "
" " < + '(+ ("("! + +>% 4 9
QueryTree7 + (" , " - "! + +>% "! " !" (>%6
*! ! , "! + , " - .! * " '(("! Set/Get-
BufferAttributes '("

A "! + +>% " + + + '("4 9 GetImage7 ("
0 "!") "* "!" "! " !" "
+ 1(" " 4 0 " *" + !, "
+ "" " 0 *" ("! " !" (>%6 " (** (* "
"*! " " 7

:, 0 *" CreateStereoWindow '(" ! ("!" ,
"" + - + "! " +!"! " + + *
"(" ""(" "! * " "* " (""! (*" "

! + (" " " " ! +"!
", "* (" 0 "! , "* (" "
! "!" " *" "! "! ("
"! (! (" "! 0" 4 9 , " *
*! ! + 7 .! * "" (" 4 9 08 (" 7
* "!" (" + + * "!" (" "
+ +O !+, + + " "! *
(" !, "! * "" (" 4 9 0 *" " 7

> * "!" (" " + + (" + + "! "!
" " "! " !" + + !("!
4 9 !, " "7

Single-Buffered Stereo Windows

.! + !+ !+" * " (" 9

```
/*
 * Create the stereo window, map it the screen,
 * and draw the left and right images
 */
CreateStereoWindow( W, L, R, ... )

MapWindow( W )

<draw picture using L,R>
```

Double-Buffering Stereo Windows

= " (" " + +" + ((
" (" ("! "! CreateImageBuffers '(" &,
((4L I 7 + " (; ((4 7 +
 !" (% " * *(" , "8 !"
  (0 4 (PLQ (P Q7 "! " "
 O 4 (PIQ (P Q7 "! 0"O

.! CreateImageBuffers '(" + * " " !"
(" + + G + " !" (" "!
 " " !" " " H " > (
 (* Value " = "! (" ""!
" " "! " " "! ((" " + +

. ((" (" "! "! " (
>% !" (>% * DisplayImageBuffers '(" (" "
 "!

. ((" + +9

```
/*
 * Create stereo window and map it to the screen
 */
CreateStereoWindow( W, L, R, ... )

/*
 * Create two pairs of image buffers.  Assume after display,
 * buffer contents become "undefined".  Assume we will "frequently"
 * update the display.  Abort if we did get all the buffers.
 */
n = CreateImageBuffers( W, [L0,R0,L1,R1], Undefined, Frequently )
if (n != 4) <abort>

/*
 * Map window to the screen
```

```
 */
MapWindow( W )

/*
 * Draw images using alternate buffers,
 * display every 1/10 of a second.
 */
while animating
{
     <draw picture using L1,R1>
     DisplayImageBuffers( [L1], 100, 0 )

     <draw picture using L0,R0>
     DisplayImageBuffers( [L0], 100, 0 )
}
```

Multi-Buffering Stereo Windows

. * * "! (! , " 9

```
/*
 * Create stereo window
 */
CreateStereoWindow( W, L, R, ... )

/*
 * Create N pairs of image buffers.  Assume after display,
 * buffer contents are "untouched".  Assume we will "frequently"
 * update the display.  Abort if we don't get all the buffers.
 */
n = CreateImageBuffers( W, [L0,R0,...,L(N-1),R(N-1)], Untouched, Frequently )
if (n != N*2) <abort>

/*
 * Map window to screen
 */
MapWindow( W )

/*
 * Draw the left and right halves of each image
 */
foreach stereo image
     <draw picture using L(i),R(i)>

/*
 * Cycle through images every 1/10 of a second
 */
while animating
{
     foreach stereo image
          DisplayImageBuffers( [L(i)], 100, 0 )
}
```

Protocol Encoding

.! * "! 0" /E(" G(/ <! "! " "
QueryExtension "! " "(! (" " + 9

1 * * "! 1 * "! 0" .! " " *!
0" '(" ! (* "! , (

" , " * "! * "! " + "(+! ClobberNotify
, " "

" * "! * "! " + "(+! Buffer
"

.! + *" * "! " * * "! 0"

Chapter 8. TYPES

```
BUFFER_INFO

4       VISUALID     visual
2       CARD16       max-buffers
1       CARD8        depth
1                    unused


SETofBUFFER_EVENT

        #x00008000   Exposure
        #x02000000   ClobberNotify
        #x04000000   UpdateNotify
```

Chapter 9. EVENTS

```
ClobberNotify
1       see first-event code
1                                unused
2       CARD16                   sequence number
4       BUFFER                   buffer
1                                state
        0 Unclobbered
        1 PartiallyClobbered
        2 FullyClobbered
23                                unused


UpdateNotify
1 first-event+1 code
1                        unused
2      CARD16            sequence number
4      BUFFER            buffer
24                       unused
```

Chapter 10. ERRORS

```
Buffer
1     0                 Error
1     see first-error code
2     CARD16                  sequence number
4     CARD32                  bad resource id
2     CARD16                  minor-opcode
1     CARD8                   major-opcode
21                            unused
```

Chapter 11. REQUESTS

```
GetBufferVersion
1       see major-opcode        major-opcode
1       0                   minor-opcode
2       1                   request length
->
1       1                   Reply
1                           unused
2       CARD16              sequencenumber
4       0                   reply length
1       CARD8               majorversion number
1       CARD8               minorversion number
22                          unused


CreateImageBuffers

1        see major-opcode   major-opcode
1        1                  minor-opcode
2        3+n                requestlength
4        WINDOW             wid
1                           update-action
         0 Undefined
         1 Background
         2 Untouched
         3 Copied
1                           update-hint
         0 Frequent
         1 Intermittent
         2 Static
2                           unused
4n     LISTofBUFFER         buffer-list
->
1        1                  Reply
1                           unused
2      CARD16               sequencenumber
4      0                    reply length
2      CARD16               number-buffers
22                          unused


DestroyImageBuffers

1        see major-opcode   major-opcode
1       2                   minor-opcode
2       2                   request length
4       WINDOW              wid


DisplayImageBuffers
```

```
1        see major-opcode  major-opcode
2        2+n               requestlength
2        CARD16            min-delay
2        CARD16            max-delay
4n       LISTofBUFFER      buffer-list


SetMultiBufferAttributes

1        see major-opcode  major-opcode
1        4                 minor-opcode
2        3+n               requestlength
4        WINDOW            wid
4        BITMASK           value-mask (has n bits set to 1)
         #x00000001        update-hint
4n        LISTofVALUE      value-list
VALUEs
1                          update-hint
         0 Frequent
         1 Intermittent
         2 Static


GetMultiBufferAttributes

1        see major-opcode  major-opcode
1        5                 minor-opcode
2        2                 request length
4        WINDOW            wid
®
1        1                 Reply
1                          unused
2        CARD16            sequencenumber
4        n                 reply length
2        CARD16            displayed-buffer
1                          update-action
         0 Undefined
         1 Background
         2 Untouched
         3 Copied
1                          update-hint
         0 Frequent
         1 Intermittent
         2 Static
1                          window-mode
         0 Mono
         1 Stereo
19                         unused
4n       LISTofBUFFER      buffer list


SetBufferAttributes
```

```
1         see major-opcode  major-opcode
1         6                 minor-opcode
2         3+n               requestlength
4         BUFFER            buffer
4         BITMASK           value-mask (has n bits set to 1)
          #x00000001        event-mask
4n        LISTofVALUE       value-list
VALUEs
4         SETofBUFFER_EVENT event-mask

GetBufferAttributes

1         see major-opcode  major-opcode
1         7                 minor-opcode
2         2                 request length
4         BUFFER            buffer
->
1         1                 Reply
1                           unused
2         CARD16            sequencenumber
4         0                 reply length
4         WINDOW            wid
4         SETofBUFFER_EVENT event-mask
2         CARD16            index
          1 side
          0 Mono
          1 Left
          2 Right
13                          unused

GetBufferInfo

1         see major-opcode  major-opcode
1         8                   minor-opcode
2         2                   request length
4         WINDOW              root
®
1         1                   Reply
1                             unused
2         CARD16              sequencenumber
4         2(n+m)              replylength
2         n                   number BUFFER_INFO in normal-info
2         m                   number BUFFER_INFO in stereo-info
20                            unused
8n        LISTofBUFFER_INFO   normal-info
8m        LISTofBUFFER_INFO   stereo-info

CreateStereoWindow

1         see major-opcode  major-opcode
1         9 minor-opcode
2         11+n                    requestlength
3                                 unused
```

```
1        CARD8                  depth
4        WINDOW                 wid
4        WINDOW                 parent
4        BUFFER                 left
4        BUFFER                 right
2        INT16                  x
2        INT16                  y
2        CARD16                 width
2        CARD16                 height
2        CARD16                 border-width
2                               class
         0 CopyFromParent
         1 InputOutput
         2 InputOnly
4        VISUALID               visual
         0 CopyFromParent
4        BITMASK                value-mask (has n bits set to 1)
         encodings are the same
         as for CreateWindow
4n       LISTofVALUE            value-list
         encodings are the same
         as for CreateWindow


ClearImageBufferArea

1 see major-opcode major-opcode
1        10                     minor-opcode
2        5                      request length
4        WINDOW                 buffer
2        INT16                  x
2        INT16                  y
2        CARD16                 width
2        CARD16                 height
3                               unused
1        BOOL                   exposures
```