X Synchronization Extension Protocol

X Consortium Standard

Tim Glauert, Olivetti Research/MultiWorks
Dave Carver
Digital Equipment Corporation, MIT/Project Athena
Jim Gettys
Digital Equipment Corporation, Cambridge Research Laboratory
David Wiggins
X Consortium, Inc.

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by Tim Glauert
Dave Carver
Digital Equipment Corporation, MIT/Project Athena
Jim Gettys
Digital Equipment Corporation, Cambridge Research Laboratory
David Wiggins
X Consortium, Inc.

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Chapter 1. Synchronization Protocol

The core X protocol makes no guarantees about the relative order of execution of requests for different clients. This means that any synchronization between clients must be done at the client level in an operating system-dependent and network-dependent manner. Even if there was an accepted standard for such synchronization, the use of a network introduces unpredictable delays between the synchronization of the clients and the delivery of the resulting requests to the X server.

The core X protocol also makes no guarantees about the time at which requests are executed, which means that all clients with real-time constraints must implement their timing on the host computer. Any such timings are subject to error introduced by delays within the operating system and network and are inefficient because of the need for round-trip requests that keep the client and server synchronized.

The synchronization extension provides primitives that allow synchronization between clients to take place entirely within the X server. This removes any error introduced by the network and makes it possible to synchronize clients on different hosts running different operating systems. This is important for multimedia applications, where audio, video, and graphics data streams are being synchronized. The extension also provides internal timers within the X server to which client requests can be synchronized. This allows simple animation applications to be implemented without any round-trip requests and makes best use of buffering within the client, network, and server.

Description

The mechanism used by this extension for synchronization within the X server is to block the processing of requests from a client until a specific synchronization condition occurs. When the condition occurs, the client is released and processing of requests continues. Multiple clients may block on the same condition to give inter-client synchronization. Alternatively, a single client may block on a condition such as an animation frame marker.

The extension adds `Counter` and `Alarm` to the set of resources managed by the server. A counter has a 64-bit integer value that may be increased or decreased by client requests or by the server internally. A client can block by sending an Await request that waits until one of a set of synchronization conditions, called TRIGGERs, becomes TRUE.

The `CreateCounter` request allows a client to create a `Counter` that can be changed by explicit `SetCounter` and `ChangeCounter` requests. These can be used to implement synchronization between different clients.

There are some counters, called `System Counters`, that are changed by the server internally rather than by client requests. The effect of any change to a system counter is not visible until the server has finished processing the current request. In other words, system counters are apparently updated in the gaps between the execution of requests rather than during the actual execution of a request. The extension provides a system counter that advances with the server time as defined by the core protocol, and it may also provide counters that advance with the real-world time or that change each time the CRT screen is refreshed. Other extensions may provide their own extension-specific system counters.

The extension provides an `Alarm` mechanism that allows clients to receive an event on a regular basis when a particular counter is changed.

Types

Please refer to the X11 Protocol specification as this document uses syntactic conventions established there and references types defined there.

The following new types are used by the extension.

```
INT64:                  64-bit signed integer
COUNTER:                XID
VALUETYPE:              {Absolute,Relative};
TESTTYPE:               {PositiveTransition,NegativeTransition,
                         PositiveComparison,NegativeComparison}
TRIGGER:                [
                         counter:COUNTER,
                         value-type:VALUETYPE,
                         wait-value:INT64,
                         test-type:TESTTYPE
                        ]
WAITCONDITION:          [
                         trigger:TRIGGER,
                         event-threshold:INT64
                        ]
SYSTEMCOUNTER:          [
                         name:STRING8,
                         counter:COUNTER,
                         resolution:INT64
                        ]
ALARM:                  XID
ALARMSTATE:             {Active,Inactive,Destroyed}
```

The COUNTER type defines the client-side handle on a server `Counter`. The value of a counter is an INT64.

The TRIGGER type defines a test on a counter that is either TRUE or FALSE. The value of the test is determined by the combination of a test value, the value of the counter, and the specified test-type.

The test value for a trigger is calculated using the value-type and wait-value fields when the trigger is initialized. If the value-type field is not one of the named VALUETYPE constants, the request that initialized the trigger will return a `Value` error. If the value-type field is `Absolute`, the test value is given by the wait-value field. If the value-type field is `Relative`, the test value is obtained by adding the wait-value field to the value of the counter. If the resulting test value would lie outside the range for an INT64, the request that initialized the trigger will return a `Value` error. If counter is `None` and the value-type is `Relative`, the request that initialized the trigger will return a `Match` error. If counter is not None and does not name a valid counter, a Counter error is generated.

If the test-type is `PositiveTransition`, the trigger is initialized to FALSE, and it will become TRUE when the counter changes from a value less than the test value to a value greater than or equal to the test value. If the test-type is `NegativeTransition`, the trigger is initialize to FALSE, and it will become TRUE when the counter changes from a value greater than the test value to a value less than or equal to the test value. If the test-type is `PositiveComparison`, the trigger is TRUE if the counter is greater than or equal to the test value and FALSE otherwise. If the test-type is `NegativeComparison`, the trigger is TRUE if the counter is less than or equal to the test value and FALSE otherwise. If the test-type is not one of the named TESTTYPE constants, the request that initialized the trigger will return a Value error. A trigger with a counter value of `None` and a valid test-type is always TRUE.

The WAITCONDITION type is simply a trigger with an associated event-threshold. The event threshold is used by the `Await` request to decide whether or not to generate an event to the client after the trigger has become TRUE. By setting the event-threshold to an appropriate value, it is possible to detect the situation where an `Await` request was processed after the TRIGGER became TRUE, which usually indicates that the server is not processing requests as fast as the client expects.

The SYSTEMCOUNTER type provides the client with information about a `System-`Counter. The name field is the textual name of the counter that identifies the counter to the client. The counter field is the client-side handle that should be used in requests that require a counter. The resolution field gives the approximate step size of the system counter. This is a hint to the client that the extension may not be able to resolve two wait conditions with test values that differ by less than this step size. A microsecond clock, for example, may advance in steps of 64 microseconds, so a counter based on this clock would have a resolution of 64.

The only system counter that is guaranteed to be present is called SERVERTIME, which counts milliseconds from some arbitrary starting point. The least significant 32 bits of this counter track the value of Time used by the server in Events and Requests. Other system counters may be provided by different implementations of the extension. The X Consortium will maintain a registry of system counter names to avoid collisions in the name space.

An ALARM is the client-side handle on an `Alarm` resource.

Errors

Counter	This error is generated if the value for a COUNTER argument in a request does not name a defined COUNTER.
Alarm	This error is generated if the value for an ALARM argument in a request does not name a defined ALARM.

Requests

Initialize

```
version-major,version-minor: CARD8
=>
version-major,version-minor: CARD8
```

This request must be executed before any other requests for this extension. If a client violates this rule, the results of all SYNC requests that it issues are undefined. The request takes the version number of the extension that the client wishes to use and returns the actual version number being implemented by the extension for this client. The extension may return different version numbers to a client depending of the version number supplied by that client. This request should be executed only once for each client connection.

Given two different versions of the SYNC protocol, v1 and v2, v1 is compatible with v2 if and only if v1.version_major = v2.version_major and v1.version_minor <= v2.version_minor. Compatible means that the functionality is fully supported in an identical fashion in the two versions.

This document describes major version 3, minor version 0 of the SYNC protocol.

ListSystemCounters

```
=>
system-counters: LISTofSYSTEMCOUNTER
Errors: Alloc
```

This request returns a list of all the system counters that are available at the time the request is executed, which includes the system counters that are maintained by other extensions. The list returned by this request may change as counters are created and destroyed by other extensions.

CreateCounter

```
id: COUNTER
initial-value: INT64
Errors: IDChoice,Alloc
```

This request creates a counter and assigns the specified id to it. The counter value is initialized to the specified initial-value and there are no clients waiting on the counter.

DestroyCounter

```
counter: COUNTER
Errors: Counter,Access
```

This request destroys the given counter and sets the counter fields for all triggers that specify this counter to `None`. All clients waiting on the counter are released and a `CounterNotify` event with the destroyed field set to TRUE is sent to each waiting client, regardless of the event-threshold. All alarms specifying the counter become `Inactive` and an `AlarmNotify` event with a state field of `Inactive` is generated. A counter is destroyed automatically when the connection to the creating client is closed down if the close-down mode is Destroy. An `Access` error is generated if counter is a system counter. A `Counter` error is generated if counter does not name a valid counter.

QueryCounter

```
counter: COUNTER
=>
value: INT64
Errors: Counter
```

This request returns the current value of the given counter or a generates Counter error if counter does not name a valid counter.

Await

```
wait-list: LISTofWAITCONDITION
Errors: Counter,Alloc,Value
```

When this request is executed, the triggers in the wait-list are initialized using the wait-value and value-type fields, as described in the definition of TRIGGER above. The processing of further requests for the client is blocked until one or more of the triggers becomes TRUE. This may happen immediately, as a result of the initialization, or at some later time, as a result of a subsequent `SetCounter`, `ChangeCounter` or `DestroyCounter` request.

A Value error is generated if wait-list is empty.

When the client becomes unblocked, each trigger is checked to determine whether a `CounterNotify` event should be generated. The difference between the counter and the test value is calculated by subtracting the test value from the value of the counter. If the test-type is `PositiveTransition` or `PositiveComparison`, a `CounterNotify` event is generated if the difference is at least event-threshold. If the test-type is `NegativeTransition` or `NegativeComparison`, a `CounterNotify` event is generated if the difference is at most event-threshold. If the difference lies outside the range for an INT64, an event is not generated.

This threshold check is made for each trigger in the list and a `CounterNotify` event is generated for every trigger for which the check succeeds. The check for `CounterNotify` events is performed even if one of the triggers is TRUE when the request is first executed. Note that a `CounterNotify` event may be generated for a trigger that is FALSE if there are multiple triggers in the request. A `CounterNotify` event with the destroyed flag set to TRUE is always generated if the counter for one of the triggers is destroyed.

ChangeCounter

```
counter: COUNTER
amount: INT64
Errors: Counter,Access,Value
```

This request changes the given counter by adding amount to the current counter value. If the change to this counter satisfies a trigger for which a client is waiting, that client is unblocked and one or more `CounterNotify` events may be generated. If the change to the counter satisfies the trigger for an alarm, an `AlarmNotify` event is generated and the alarm is updated. An `Access` error is generated if counter is a system counter. A `Counter` error is generated if counter does not name a valid counter. If the resulting value for the counter would be outside the range for an INT64, a `Value` error is generated and the counter is not changed.

It should be noted that all the clients whose triggers are satisfied by this change are unblocked, so this request cannot be used to implement mutual exclusion.

SetCounter

```
counter: COUNTER
value: INT64
Errors: Counter,Access
```

This request sets the value of the given counter to value. The effect is equivalent to executing the appropriate ChangeCounter request to change the counter value to value. An Access error is generated if counter names a system counter. A Counter error is generated if counter does not name a valid counter.

CreateAlarm

```
id: ALARM
values-mask: CARD32
values-list: LISTofVALUE
left">Errors: IDChoice,Counter,Match,Value,Alloc
```

This request creates an alarm and assigns the identifier id to it. The values-mask and values-list specify the attributes that are to be explicitly initialized. The attributes for an Alarm and their defaults are:

Attribute	Type	Default	
trigger	TRIGGER	counter	None
		value-type	Absolute
		value	0
		test-type	PositiveComparison
delta	INT64	1	
events	BOOL	TRUE	

The trigger is initialized as described in the definition of TRIGGER, with an error being generated if necessary.

If the counter is `None`, the state of the alarm is set to `Inactive`, else it is set to Active.

Whenever the trigger becomes TRUE, either as a result of this request or as the result of a `SetCounter`, `ChangeCounter`, `DestroyCounter`, or `ChangeAlarm` request, an `AlarmNotify` event is generated and the alarm is updated. The alarm is updated by repeatedly adding delta to the value of the trigger and reinitializing it until it becomes FALSE. If this update would cause value to fall outside the range for an INT64, or if the counter value is `None`, or if the delta is 0 and test-type is `PositiveComparison` or `NegativeComparison`, no change is made to value and the alarm state is changed to `Inactive` before the event is generated. No further events are generated by an `Inactive` alarm until a `ChangeAlarm` or `DestroyAlarm` request is executed.

If the test-type is `PositiveComparison` or `PositiveTransition and` delta is less than zero, or if the test-type is `NegativeComparison` or `NegativeTransition` and delta is greater than zero, a `Match` error is generated.

The events value enables or disables delivery of `AlarmNotify` events to the requesting client. The alarm keeps a separate event flag for each client so that other clients may select to receive events from this alarm.

An `AlarmNotify` event is always generated at some time after the execution of a `CreateAlarm` request. This will happen immediately if the trigger is TRUE, or it will happen later when the trigger becomes TRUE or the Alarm is destroyed.

ChangeAlarm

```
id: ALARM
values-mask: CARD32
values-list: LISTofVALUE
Errors: Alarm,Counter,Value,Match
```

This request changes the parameters of an Alarm. All of the parameters specified for the `CreateAlarm` request may be changed using this request. The trigger is reinitialized and an `AlarmNotify` event is generated if appropriate, as explained in the description of the `CreateAlarm` request.

Changes to the events flag affect the event delivery to the requesting client only and may be used by a client to select or deselect event delivery from an alarm created by another client.

The order in which attributes are verified and altered is server-dependent. If an error is generated, a subset of the attributes may have been altered.

DestroyAlarm

```
alarm: ALARM
Errors: Alarm
```

This request destroys an alarm. An alarm is automatically destroyed when the creating client is closed down if the close-down mode is `Destroy`. When an alarm is destroyed, an `AlarmNotify` event is generated with a state value of `Destroyed`.

QueryAlarm

```
alarm: ALARM
=>
trigger: TRIGGER
delta: INT64
events: ALARMEVENTMASK
state: ALARMSTATE
Errors: Alarm
```

This request retrieves the current parameters for an Alarm.

SetPriority

```
client-resource: XID
priority: INT32
Errors: Match
```

This request changes the scheduling priority of the client that created client-resource. If client-resource is `None`, then the priority for the client making the request is changed. A `Match` error is generated if client-resource is not `None` and does not name an existing resource in the server. For any two priority values, A and B, A is higher priority if and only if A is greater than B.

The priority of a client is set to 0 when the initial client connection is made.

The effect of different client priorities depends on the particular implementation of the extension, and in some cases it may have no effect at all. However, the intention is that higher priority clients will have their requests executed before those of lower priority clients.

For most animation applications, it is desirable that animation clients be given priority over nonrealtime clients. This improves the smoothness of the animation on a loaded server. Because a server is free to implement very strict priorities, processing requests for the highest priority client to the exclusion of all others, it is important that a client that may potentially monopolize the whole server, such as an animation that produces continuous output as fast as it can with no rate control, is run at low rather than high priority.

GetPriority

```
client-resource: XID
=>
priority: INT32
Errors: Match
```

This request returns the scheduling priority of the client that created client-resource. If client-resource is `None`, then the priority for the client making the request is returned. A `Match` error is generated if client-resource is not `None` and does not name an existing resource in the server.

Events

CounterNotify

```
counter: COUNTER
wait-value: INT64
counter-value: INT64
time: TIME
count: CARD16
destroyed: BOOL
```

`CounterNotify` events may be generated when a client becomes unblocked after an `Await` request has been processed. The wait-value is the value being waited for, and counter-value is the actual value of the counter at the time the event was generated. The destroyed flag is TRUE if this request was generated as the result of the destruction of the counter and FALSE otherwise. The time is the server time at which the event was generated.

When a client is unblocked, all the `CounterNotify` events for the Await request are generated contiguously. If count is 0, there are no more events to follow for this request. If count is n, there are at least n more events to follow.

AlarmNotify

```
alarm: ALARM
counter-value: INT64
alarm-value: INT64
state: ALARMSTATE
time: TIME
```

An `AlarmNotify` event is generated when an alarm is triggered. alarm-value is the test value of the trigger in the alarm when it was triggered, counter-value is the value of the counter that triggered the alarm, and time is the server time at which the event was generated. The state is the new state of the alarm. If state is `Inactive`, no more events will be generated by this alarm until a `ChangeAlarm` request is executed, the alarm is destroyed, or the counter for the alarm is destroyed.

Chapter 2. Encoding

Please refer to the X11 Protocol Encoding document as this section uses syntactic conventions established there and references types defined there.

The name of this extension is "SYNC".

Encoding New Types

The following new types are used by the extension.

```
ALARM: CARD32
ALARMSTATE:
       0         Active
       1         Inactive
       2         Destroyed
COUNTER: CARD32
INT64: 64-bit signed integer
SYSTEMCOUNTER:
       4         COUNTER                 counter
       8         INT64                   resolution
       2         n                       length of name in bytes
       n         STRING8                 name
       p                                 pad,p=pad(n+2)
TESTTYPE:
       0         PositiveTransition
       1         NegativeTransition
       2         PositiveComparison
       3         NegativeComparison
TRIGGER:
       4         COUNTER                 counter
       4         VALUETYPE               wait-type
       8         INT64                   wait-value
       4         TESTTYPE                test-type  VALUETYPE:
       0         Absolute
       1         Relative
WAITCONDITION:
       20        TRIGGER                 trigger
       8         INT64                   event threshold
```

An INT64 is encoded in 8 bytes with the most significant 4 bytes first followed by the least significant 4 bytes. Within these 4-byte groups, the byte ordering determined during connection setup is used.

Encoding Errors

```
Counter
        1    0            Error
        1    Base + 0     code
        2    CARD16       sequence number
        4    CARD32       bad counter
```

```
        2    CARD16       minor opcode
        1    CARD8        major opcode
        21                unused
Alarm
        1    0            Error
        1    Base + 1     code
        2    CARD16       sequence number
        4    CARD32       bad alarm
        2    CARD16       minor opcode
        1    CARD8        major opcode
        21                unused
```

Encoding Requests

```
Initialize
        1    CARD8        major opcode
        1    0            minor opcode
        2    2            request length
        1    CARD8        major version
        1    CARD8        minor version
        2                 unused
=>
        1    1            Reply
        1                 unused
        2    CARD16       sequence number
        4    0            reply length
        1    CARD8        major version
        1    CARD8        minor version
        2                 unused
        20                unused

ListSystemCounters
        1    CARD8                  major opcode
        1    1                      minor opcode
        2    1                      request length
=>
        1    1                      Reply
        1                           unused
        2    CARD16                 sequence number
        4    0                      reply length
        4    INT32                  list length
        20                          unused
        4n   list of SYSTEMCOUNTER  system counters

CreateCounter
        1    CARD8                  major opcode
        1    2                      minor opcode
        2    4                      request length
        4    COUNTER                id
        8    INT64                  initial value

DestroyCounter
```

```
        1    CARD8                  major opcode
        1    6                      minor opcode[1]
        2    2                      request length
        4    COUNTER                counter
=>
        1    1                      Reply
        1                           unused
        2    CARD16                 sequence number
        4    0                      reply length
        8    INT64                  counter value
        16                          unused

Await
        1    CARD8                  major opcode
        1    7                      minor opcode[2]
        2    1 + 7*n                request length
        28n  LISTofWAITCONDITION    wait conditions

ChangeCounter
        1    CARD8                  major opcode
        1    4                      minor opcode[3]
        2    4                      request length
        4    COUNTER                counter
        8    INT64                  amount

SetCounter
        1    CARD8                  major opcode
        1    3                      minor opcode[4]
        2    4                      request length
        4    COUNTER                counter
        8    INT64                  value

CreateAlarm
        1    CARD8                  major opcode
        1    8                      minor opcode
        2    3+n                    request length
        4    ALARM                  id
        4    BITMASK                values mask

             #x00000001             counter
             #x00000002             value-type
             #x00000004             value
             #x00000008             test-type
             #x00000010             delta
             #x00000020             events

        4n   LISTofVALUE            values

VALUES
```

---

[1] A previous version of this document gave an incorrect minor opcode

[2] A previous version of this document gave an incorrect minor opcode.

[3] A previous version of this document gave an incorrect minor opcode.

[4] A previous version of this document gave an incorrect minor opcode.

```
        4    COUNTER               counter
        4    VALUETYPE             value-type
        8    INT64                 value
        4    TESTTYPE              test-type
        8    INT64                 delta
        4    BOOL                  events

ChangeAlarm
        1    CARD8                 major opcode
        1    9                     minor opcode
        2    3+n                   request length
        4    ALARM                 id
        4    BITMASK               values mask
             encodings as for CreateAlarm
        4n   LISTofVALUE           values
             encodings as for CreateAlarm

DestroyAlarm
        1    CARD8       major opcode
        1    11          minor opcode[5]
        2    2           request length
        4    ALARM       alarm

QueryAlarm
        1    CARD8       major opcode
        1    10          minor opcode[6]
        2    2           request length
        4    ALARM       alarm
=>
        1    1           Reply
        1                unused
        2    CARD16      sequence number
        4    2           reply length
        20   TRIGGER     trigger
        8    INT64       delta
        1    BOOL        events
        1    ALARMSTATE  state
        2                unused

SetPriority
        1    CARD8       major opcode
        1    12          minor opcode
        2    3           request length
        4    CARD32      id
        4    INT32       priority

GetPriority
        1    CARD8       major opcode
        1    13          minor opcode
        2    1           request length
        4    CARD32      id
```

---

[5] A previous version of this document gave an incorrect minor opcode.

[6] A previous version of this document gave an incorrect minor opcode.

```
=>
        1    1            Reply
        1                 unused
        2    CARD16       sequence number
        4    0            reply length
        4    INT32        priority
        20                unused
```

Encoding Events

```
CounterNotify
        1    Base + 0     code
        1    0            kind
        2    CARD16       sequence number
        4    COUNTER      counter
        8    INT64        wait value
        8    INT64        counter value
        4    TIME         timestamp
        2    CARD16       count
        1    BOOL         destroyed
        1                 unused

AlarmNotify
        1    Base + 1     code
        1    1            kind
        2    CARD16       sequence number
        4    ALARM        alarm
        8    INT64        counter value
        8    INT64        alarm value
        4    TIME         timestamp
        1    ALARMSTATE   state
        3                 unused
```