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## Taxonomy of Communication Requirements for Large-scale Multicast Applications

### Status of this Memo

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### Abstract

The intention of this memo is to define a classification system for the communication requirements of any large-scale multicast application (LSMA). It is very unlikely one protocol can achieve a compromise between the diverse requirements of all the parties involved in any LSMA. It is therefore necessary to understand the worst-case scenarios in order to minimize the range of protocols needed. Dynamic protocol adaptation is likely to be necessary which will require logic to map particular combinations of requirements to particular mechanisms. Standardizing the way that applications define their requirements is a necessary step towards this. Classification is a first step towards standardization.

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## 1. Introduction

This taxonomy consists of a large number of parameters that are considered useful for describing the communication requirements of LSMAs. To describe a particular application, each parameter would be assigned a value. Typical ranges of values are given wherever possible. Failing this, the type of any possible values is given. The parameters are collected into ten or so higher level categories, but this is purely for convenience.

The parameters are pitched at a level considered meaningful to application programmers. However, they describe communications not applications - the terms '3D virtual world', or 'shared TV' might imply communications requirements, but they don't accurately describe them. Assumptions about the likely mechanism to achieve each requirement are avoided where possible.

While the parameters describe communications, it will be noticed that few requirements concerning routing etc. are apparent. This is because applications have few direct requirements on these second order aspects of communications. Requirements in these areas will have to be inferred from application requirements (e.g. latency).

The taxonomy is likely to be useful in a number of ways:

1. Most simply, it can be used as a checklist to create a requirements statement for a particular LSMA. Example applications will be classified [bagnall98] using the taxonomy in order to exercise (and improve) it
2. Because strictest requirement have been defined for many parameters, it will be possible to identify worst case scenarios for the design of protocols
3. Because the scope of each parameter has been defined (per session, per receiver etc.), it will be possible to highlight where heterogeneity is going to be most marked
4. It is a step towards standardization of the way LSMAs define their communications requirements. This could lead to standard APIs between applications and protocol adaptation middleware
5. Identification of limitations in current Internet technology for LSMAs to be added to the LSMA limitations memo [limitations]
6. Identification of gaps in Internet Engineering Task Force (IETF) working group coverage

This approach is intended to complement that used where application scenarios for Distributed Interactive Simulation (DIS) are proposed in order to generate network design metrics (values of communications parameters). Instead of creating the communications parameters from the applications, we try to imagine applications that might be enabled by stretching communications parameters.

## 2. Definition of Sessions

The following terms have no agreed definition, so they will be defined for this document.

### Session

a happening or gathering consisting of flows of information related by a common description that persists for a non-trivial time (more than a few seconds) such that the participants (be they humans or applications) are involved and interested at intermediate times. A session may be defined recursively as a super-set of other sessions.

### Secure session

a session with restricted access

A session or secure session may be a sub and/or super set of a multicast group. A session can simultaneously be both a sub and a super-set of a multicast group by spanning a number of groups while time-sharing each group with other sessions.

### 3. Taxonomy

#### 3.1 Summary of Communications Parameters

Before the communications parameters are defined, typed and given worst-case values, they are simply listed for convenience. Also for convenience they are collected under classification headings.

Reliability . . . . .	3.2.1
Packet loss . . . . .	3.2.1.1
Transactional	
Guaranteed	
Tolerated loss	
Semantic loss	
Component reliability . . . . .	3.2.1.2
Setup fail-over time	
Mean time between failures	
Fail over time during a stream	
Ordering . . . . .	3.2.2
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Timeliness . . . . .	3.2.3
Hard Realtime	
Synchronicity	
Burstiness	
Jitter	
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Tolerable bandwidth	
Required by time and tolerance	
Host performance	
Fair delay	
Frame size	
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Initiation	
Start time	
End time	
Duration	
Active time	
Session Burstiness	
Atomic join	
Late join allowed ?	

Temporary leave allowed ?	
Late join with catch-up allowed ?	
Potential streams per session	
Active streams per sessions	
Session Topology . . . . .	3.2.5
Number of senders	
Number of receivers	
Directory . . . . .	3.2.6
Fail-over time-out (see Reliability: fail-over time)	
Mobility	
Security . . . . .	3.2.7
Authentication strength	
Tamper-proofing	
Non-repudiation strength	
Denial of service	
Action restriction	
Privacy	
Confidentiality	
Retransmit prevention strength	
Membership criteria	
Membership principals	
Collusion prevention	
Fairness	
Action on compromise	
Security dynamics . . . . .	3.2.8
Mean time between compromises	
Compromise detection time limit	
Compromise recovery time limit	
Payment & Charging . . . . .	3.2.9
Total Cost	
Cost per time	
Cost per Mb	

### 3.2 Definitions, types and strictest requirements

The terms used in the above table are now defined for the context of this document. Under each definition, the type of their value is given and where possible worst-case values and example applications that would exhibit this requirement.

There is no mention of whether a communication is a stream or a discrete interaction. An attempt to use this distinction as a way of characterizing communications proved to be remarkably unhelpful and was dropped.

### 3.2.1 Types

Each requirement has a type. The following is a list of all the types used in the following definitions.

#### Application Benchmark

This is some measure of the processor load of an application, in some architecture neutral unit. This is non-trivial since the processing an application requires may change radically with different hardware, for example, a video client with and without hardware support.

Bandwidth Measured in bits per second, or a multiple of.

#### Boolean

#### Abstract Currency

An abstract currency is one which is adjusted to take inflation into account. The simplest way of doing this is to use the value of a real currency on a specific date. It is effectively a way of assessing the cost of something in "real terms". An example might be 1970 US\$. Another measure might be "average man hours".

#### Currency - current local

#### Data Size

#### Date (time since epoch)

#### Enumeration

#### Fraction

#### Identifiers

A label used to distinguish different parts of a communication

#### Integer

#### Membership list/rule

#### Macro

A small piece of executable code used to describe policies

#### Time

### 3.2.2 Reliability

#### 3.2.2.1 Packet Loss

##### Transactional

When multiple operations must occur atomically, transactional communications guarantee that either all occur or none occur and a failure is flagged.

Type: Boolean  
Meaning: Transactional or Not transaction  
Strictest Requirement: Transactional  
Scope: per stream  
Example Application: Bank credit transfer, debit and credit must be atomic.  
NB: Transactions are potentially much more complex, but it is believed this is an application layer problem.

##### Guaranteed

Guarantees communications will succeed under certain conditions.

Type: Enumerated  
Meaning: Deferrable - if communication fails it will be deferred until a time when it will be successful.  
Guaranteed - the communication will succeed so long as all necessary components are working.  
No guarantee - failure will not be reported.  
Strictest Requirement: Deferrable  
Example Application: Stock quote feed - Guaranteed  
Scope: per stream  
NB: The application will need to set parameters to more fully define Guarantees, which the middleware may translate into, for example, queue lengths.

##### Tolerated loss

This specifies the proportion of data from a communication that can be lost before the application becomes completely unusable.

Type: Fraction  
Meaning: fraction of the stream that can be lost  
Strictest Requirement: 0%  
Scope: per stream  
Example Application: Video - 20%

#### Semantic loss

The application specifies how many and which parts of the communication can be discarded if necessary.

Type: Identifiers, name disposable application level frames  
Meaning: List of the identifiers of application frames which may be lost  
Strictest Requirement: No loss allowed  
Scope: per stream  
Example Application: Video feed - P frames may be lost, I frames not

### 3.2.2.2. Component Reliability

#### Setup Fail-over time

The time before a failure is detected and a replacement component is invoked. From the applications point of view this is the time it may take in exceptional circumstances for a channel to be set-up. It is not the "normal" operating delay before a channel is created.

Type: Time  
Strictest Requirement: Web server - 1 second  
Scope: per stream  
Example Application: Name lookup - 5 seconds

#### Mean time between failures

The mean time between two consecutive total failures of the channel.

Type: Time  
Strictest Requirement: Indefinite  
Scope: per stream  
Example Application: Telephony - 1000 hours



### Fail over time during a stream

The time between a stream breaking and a replacement being set up.

Type: Time  
Strictest Requirement: Equal to latency requirement  
Scope: per stream  
Example Application: File Transfer - 10sec

### 3.2.3. Ordering

#### Ordering type

Specifies what ordering must be preserved for the application

Type: {  
    Enumeration timing,  
    Enumeration sequencing,  
    Enumeration causality  
}

Meaning: Timing - the events are timestamped  
    Global  
    Per Sender  
    none  
    Sequencing - the events are sequenced in  
    order of occurrence  
    Global  
    Per Sender  
    none  
    Causality - the events form a graph  
    relating cause and effect  
    Global  
    Per Sender  
    none

Strictest Requirement: Global, Global, Global  
Scope: per stream  
Example Application: Game - { none, per sender, global } (to  
    make sure being hit by bullet occurs  
    after the shot is fired!)

### 3.2.4. Timeliness

#### Hard real- time

There is a meta-requirement on timeliness. If hard real-time is required then the interpretation of all the other requirements changes. Failures to achieve the required timeliness must be

reported before the communication is made. By contrast soft real-time means that there is no guarantee that an event will occur in time. However statistical measures can be used to indicate the probability of completion in the required time, and policies such as making sure the probability is 95% or better could be used.

Type: Boolean  
Meaning: Hard or Soft realtime  
Strictest Requirement: Hard  
Scope: per stream  
Example Application: Medical monitor - Hard

### Synchronicity

To make sure that separate elements of a session are correctly synchronized with respect to each other

Type: Time  
Meaning: The maximum time drift between streams  
Strictest Requirement: 80ms for human perception  
Scope: per stream pair/set  
Example Application: TV lip-sync value 80ms  
NB: the scope is not necessarily the same as the session. Some streams may no need to be sync'd, (say, a score ticker in a football match)

### Burstiness

This is a measure of the variance of bandwidth requirements over time.

Type: Fraction  
Meaning: either:  
Variation in b/w as fraction of b/w for variable b/w communications  
or  
duty cycle (fraction of time at peak b/w) for intermittent b/w communications.  
Strictest Requirement: Variation = max b/w Duty cycle ~ 0  
Scope: per stream  
Example Application: Sharing video clips, with chat channel - sudden bursts as clips are swapped.  
Compressed Audio - difference between silence and talking  
NB: More detailed analysis of communication flow (e.g. max rate of b/w change or

Fourier Transform of the b/w requirement) is possible but as complexity increases usefulness and computability decrease.

### Jitter

Jitter is a measure of variance in the time taken for communications to traverse from the sender (application) to the receiver, as seen from the application layer.

Type: Time  
Meaning: Maximum permissible time variance  
Strictest Requirement: <1ms  
Scope: per stream  
Example Application: audio streaming - <1ms  
NB: A jitter requirement implies that the communication is a real-time stream. It makes relatively little sense for a file transfer for example.

### Expiry

This specifies how long the information being transferred remains valid for.

Type: Date  
Meaning: Date at which data expires  
Strictest Requirement: For ever  
Scope: per stream  
Example Application: key distribution - now+3600 seconds (valid for at least one hour)

### Latency

Time between initiation and occurrence of an action from application perspective.

Type: Time  
Strictest Requirement: Near zero for process control apps  
Scope: per stream  
Example Application: Audio conference 20ms  
NB: Where an action consists of several distinct sequential parts the latency budget must be split over those parts. For process control the requirement may take any value.

### Optimum Bandwidth

Bandwidth required to complete communication in time

Type: Bandwidth  
Strictest Requirement: No upper limit  
Scope: per stream  
Example Application: Internet Phone 8kb/s

### Tolerable Bandwidth

Minimum bandwidth that application can tolerate

Type: Bandwidth  
Strictest Requirement: No upper limit  
Scope: per stream  
Example Application: Internet phone 4kb/s

### Required by time and tolerance

Time communication should complete by and time when failure to complete renders communication useless (therefore abort).

Type: {  
    Date - preferred complete time,  
    Date - essential complete time  
}  
Strictest Requirement: Both now.  
Scope: per stream  
Example Application: Email - Preferred 5 minutes & Essential in 1 day  
NB: Bandwidth \* Duration = Size; only two of these parameters may be specified. An API though could allow application authors to think in terms of any two.

### Host performance

Ability of host to create/consume communication

Type: Application benchmark  
Meaning: Level of resources required by Application  
Strictest Requirement: Full consumption  
Scope: per stream  
Example Application: Video - consume 15 frames a second  
NB: Host performance is complex since load, media type, media quality, h/w assistance, and encoding scheme all affect the

processing load. These are difficult to predict prior to a communication starting. To some extent these will need to be measured and modified as the communication proceeds.

#### Frame size

Size of logical data packets from application perspective

Type: data size  
Strictest Requirement: 6 bytes (gaming)  
Scope: per stream  
Example Application: video = data size of single frame update

#### Content size

The total size of the content (not relevant for continuous media)

Type: data size  
Strictest Requirement: N/A  
Scope: per stream  
Example Application: document transfer, 4kbytes

### 3.2.5. Session Control

#### Initiation

Which initiation mechanism will be used.

Type: Enumeration  
Meaning: Announcement - session is publicly announced via a mass distribution system  
Invitation - specific participants are explicitly invited, e.g. my email  
Directive - specific participants are forced to join the session  
Strictest Requirement: Directive  
Scope: per stream  
Example Application: Corporate s/w update - Directive

## Start Time

Time sender starts sending!

Type: Date  
Strictest Requirement: Now  
Scope: per stream  
Example Application: FTP - at 3am

## End Time

Type: Date  
Strictest Requirement: Now  
Scope: per stream  
Example Application: FTP - Now+30mins

## Duration

(end time) - (start time) = (duration), therefore only two of three should be specified.

Type: Time  
Strictest Requirement: - 0ms for discrete, indefinite for streams  
Scope: per stream  
Example Application: audio feed - 60mins

## Active Time

Total time session is active, not including breaks

Type: Time  
Strictest Requirement: equals duration  
Scope: per stream  
Example Application: Spectator sport transmission

## Session Burstiness

Expected level of burstiness of the session

Type: Fraction  
Meaning: Variance as a fraction of maximum bandwidth  
Strictest Requirement: =bandwidth  
Scope: per stream  
Example Application: commentary & slide show: 90% of max

## Atomic join

Session fails unless a certain proportion of the potential participants accept an invitation to join. Alternatively, may be specified as a specific numeric quorum.

Type: Fraction (proportion required) or int (quorum)  
Strictest Requirement: 1.0 (proportion)  
Example Application: price list update, committee meeting  
Scope: per stream or session  
NB: whether certain participants are essential is application dependent.

## Late join allowed ?

Does joining a session after it starts make sense

Type: Boolean  
Strictest Requirement: allowed  
Scope: per stream or session  
Example Application: game - not allowed  
NB: An application may wish to define an alternate session if late join is not allowed

## Temporary leave allowed ?

Does leaving and then coming back make sense for session

Type: Boolean  
Strictest Requirement: allowed  
Scope: per stream or session  
Example Application: FTP - not allowed

## Late join with catch-up allowed ?

Is there a mechanism for a late joiner to see what they've missed

Type: Boolean  
Strictest Requirement: allowed  
Scope: per stream or session  
Example Application: sports event broadcast, allowed  
NB: An application may wish to define an alternate session if late join is not allowed

### Potential streams per session

Total number of streams that are part of session, whether being consumed or not

Type: Integer  
Strictest Requirement: No upper limit  
Scope: per session  
Example Application: football match mcast - multiple camera's, commentary, 15 streams

### Active streams per sessions (i.e. max app can handle)

Maximum number of streams that an application can consume simultaneously

Type: Integer  
Strictest Requirement: No upper limit  
Scope: per session  
Example Application: football match mcast - 6, one main video, four user selected, one audio commentary

### 3.2.6. Session Topology

Note: topology may be dynamic. One of the challenges in designing adaptive protocol frameworks is to predict the topology before the first join.

#### Number of senders

The number of senders is a result the middleware may pass up to the application

Type: Integer  
Strictest Requirement: No upper limit  
Scope: per stream  
Example Application: network MUD - 100

#### Number of receivers

The number of receivers is a results the middleware may pass up to the application

Type: Integer  
Strictest Requirement: No upper limit  
Scope: per stream  
Example Application: video mcast - 100,000



### 3.2.7. Directory

Fail-over timeout (see Reliability: fail-over time)

#### Mobility

Defines restrictions on when directory entries may be changed

Type: Enumeration

Meaning: while entry is in use  
while entry in unused  
never

Strictest Requirement: while entry is in use

Scope: per stream

Example Application: voice over mobile phone, while entry is in use (as phone gets new address when changing cell).

### 3.2.8. Security

The strength of any security arrangement can be stated as the expected cost of mounting a successful attack. This allows mechanisms such as physical isolation to be considered alongside encryption mechanisms. The cost is measured in an abstract currency, such as 1970 UD\$ (to inflation proof).

Security is an orthogonal requirement. Many requirements can have a security requirement on them which mandates that the cost of causing the system to fail to meet that requirement is more than the specified amount. In terms of impact on other requirements though, security does potentially have a large impact so when a system is trying to determine which mechanisms to use and whether the requirements can be met security will clearly be a major influence.

#### Authentication Strength

Authentication aims to ensure that a principal is who they claim to be. For each role in a communication, (e.g. sender, receiver) there is a strength for the authentication of the principle who has taken on that role. The principal could be a person, organization or other legal entity. It could not be a process since a process has no legal representation.

Type: Abstract Currency

Meaning: That the cost of hijacking a role is in excess of the specified amount. Each role is a different requirement.

Strictest Requirement: budget of largest attacker  
 Scope: per stream  
 Example Application: inter-governmental conference

#### Tamper-proofing

This allows the application to specify how much security will be applied to ensuring that a communication is not tampered with. This is specified as the minimum cost of successfully tampering with the communication. Each non-security requirement has a tamper-proofing requirement attached to it.

Requirement: The cost of tampering with the communication is in excess of the specified amount.

Type: {  
         Abstract Currency,  
         Abstract Currency,  
         Abstract Currency  
 }  
 Meaning: cost to alter or destroy data,  
           cost to replay data (successfully),  
           cost to interfere with timeliness.  
 Scope: per stream  
 Strictest Requirement: Each budget of largest attacker  
 Example Application: stock price feed

#### Non-repudiation strength

The non-repudiation strength defines how much care is taken to make sure there is a reliable audit trail on all interactions. It is measured as the cost of faking an audit trail, and therefore being able to "prove" an untrue event. There are a number of possible parameters of the event that need to be proved. The following list is not exclusive but shows the typical set of requirements.

1. Time 2. Ordering (when relative to other events) 3. Whom 4. What (the event itself)

There are a number of events that need to be provable. 1. sender proved sent 2. receiver proves received 3. sender proves received.

Type: Abstract Currency  
 Meaning: minimum cost of faking or denying an event  
 Strictest Requirement: Budget of largest attacker  
 Scope: per stream  
 Example Application: Online shopping system

## Denial of service

There may be a requirement for some systems (999,911,112 emergency services access for example) that denial of service attacks cannot be launched. While this is difficult (maybe impossible) in many systems at the moment it is still a requirement, just one that can't be met.

Type:	Abstract Currency
Meaning:	Cost of launching a denial of service attack is greater than specified amount.
Strictest Requirement:	budget of largest attacker
Scope:	per stream
Example Application:	web hosting, to prevent individual hackers stalling system.

## Action restriction

For any given communication there are a two actions, send and receive. Operations like adding to members to a group are done as a send to the membership list. Examining the list is a request to and receive from the list. Other actions can be generalized to send and receive on some communication, or are application level not comms level issues.

Type:	Membership list/rule for each action.
Meaning:	predicate for determining permission for role
Strictest Requirement:	Send and receive have different policies.
Scope:	per stream
Example Application:	TV broadcast, sender policy defines transmitter, receiver policy is null.
NB:	Several actions may share the same membership policy.

## Privacy

Privacy defines how well obscured a principals identity is. This could be for any interaction. A list of participants may be obscured, a sender may obscure their identity when they send. There are also different types of privacy. For example knowing two messages were sent by the same person breaks the strongest type of privacy even if the identity of that sender is still unknown. For each "level" of privacy there is a cost associated with violating it. The requirement is that this cost is excessive for the attacker.

Type: {  
 Abstract Currency,  
 Abstract Currency,  
 Abstract Currency,  
 Abstract Currency  
 }

Meaning: Level of privacy, expected cost to violate  
 privacy level for:-  
 openly identified - this is the unprotected  
 case  
 anonymously identified - (messages from  
 the same sender can be linked)  
 unadvertised (but traceable) - meaning that  
 traffic can be detected and traced to  
 it's source or destination, this is a  
 breach if the very fact that two  
 specific principals are communicating  
 is sensitive.  
 undetectable

Strictest Requirement: All levels budget of attacker  
 Scope: per stream  
 Example Application: Secret ballot voting system  
 openly identified - budget of any  
 interested party  
 anonymously identified - zero  
 unadvertised - zero  
 undetectable - zero

### Confidentiality

Confidentiality defines how well protected the content of a  
 communication is from snooping.

Type: Abstract Currency  
 Meaning: Level of Confidentiality, the cost of  
 gaining illicit access to the content of a  
 stream  
 Strictest Requirement: budget of attacker  
 Scope: per stream  
 Example Application: Secure email - value of transmitted  
 information

### Retransmit prevention strength

This is extremely hard at the moment. This is not to say it's not  
 a requirement.

Type: Abstract Currency  
Meaning: The cost of retransmitting a secure piece of information should exceed the specified amount.  
Strictest Requirement: Cost of retransmitting value of information  
Scope: per stream

#### Membership Criteria

If a principal attempts to participate in a communication then a check will be made to see if it is allowed to do so. The requirement is that certain principals will be allowed, and others excluded. Given the application is being protected from network details there are only two types of specification available, per user, and per organization (where an organization may contain other organizations, and each user may be a member of multiple organizations). Rules could however be built on properties of a user, for example does the user own a key? Host properties could also be used, so users on slow hosts or hosts running the wrong OS could be excluded.

Type: Macros  
Meaning: Include or exclude  
          users (list)  
          organizations (list)  
          hosts (list)  
          user properties (rule)  
          org properties (rule)  
          hosts properties (rule)  
Strictest Requirement: List of individual users  
Scope: per stream  
Example Application: Corporate video-conference - organization membership

#### Collusion prevention

Which aspects of collusion it is required to prevent. Collusion is defined as malicious co-operation between members of a secure session. Superficially, it would appear that collusion is not a relevant threat in a multicast, because everyone has the same information, however, wherever there is differentiation, it can be exploited.

Type: {  
      Abstract Currency,  
      Abstract Currency,  
      Abstract Currency

}  
 Meaning: time race collusion - cost of colluding  
 key encryption key (KEK) sharing - cost of colluding  
 sharing of differential QoS (not strictly collusion as across sessions not within one) - cost of colluding  
 Strictest Requirement: For all threats cost attackers combined resources  
 Scope: per stream  
 Example Application: A race where delay of the start signal may be allowed for, but one participant may fake packet delay while receiving the start signal from another participant.  
 NB: Time race collusion is the most difficult one to prevent. Also note that while these may be requirements for some systems this does not mean there are necessarily solutions. Setting tough requirements may result in the middleware being unable to create a valid channel.

## Fairness

Fairness is a meta-requirement of many other requirements. Of particular interest are Reliability and Timeliness requirements. When a communication is first created the creator may wish to specify a set of requirements for these parameters. Principals which join later may wish to set tighter limits. Fairness enforces a policy that any improvement is requirement by one principal must be matched by all others, in effect requirements can only be set for the whole group. This increases the likelihood that requirements of this kind will fail to be met. If fairness is not an issue then some parts of the network can use more friendly methods to achieve those simpler requirements.

Type: Level of variance of the requirement that needs to be fair. For example, if the latency requirement states within 2 seconds, the level of fairness required may be that variations in latency are not more than 0.1s. This has in fact become an issue in online gaming (e.g. Quake)  
 Meaning: The variance of performance with respect to any other requirement is less than the specified amount.  
 Scope: per stream, per requirement

Example Application: Networked game, latency to receive positions of players must be within 5ms for all players.

#### Action on compromise

The action to take on detection of compromise (until security reassured).

Type: Enumeration  
Meaning: warn but continue  
pause  
abort  
Scope: Per stream  
Strictest Requirement: pause  
Example Application: Secure video conference - if intruder alert, everyone is warned, but they can continue while knowing not to discuss sensitive matters (cf. catering staff during a meeting).

#### 3.2.8.1. Security Dynamics

Security dynamics are the temporal properties of the security mechanisms that are deployed. They may affect other requirements such as latency or simply be a reflection of the security limitations of the system. The requirements are often concerned with abnormal circumstances (e.g. system violation).

#### Mean time between compromises

This is not the same as the strength of a system. A fairly weak system may have a very long time between compromises because it is not worth breaking in to, or it is only worth it for very few people. Mean time between compromises is a combination of strength, incentive and scale.

Type: Time  
Scope: Per stream  
Strictest Requirement: indefinite  
Example Application: Secure Shell - 1500hrs

#### Compromise detection time limit

The average time it must take to detect a compromise (one predicted in the design of the detection system, that is).

Type: Time  
Scope: Per stream  
Strictest Requirement: Round trip time  
Example Application: Secure Shell - 2secs

#### Compromise recovery time limit

The maximum time it must take to re-seal the security after a breach. This combined with the compromise detection time limit defines how long the system must remain inactive to avoid more security breaches. For example if a compromise is detected in one minute, and recovery takes five, then one minute of traffic is now insecure and the members of the communication must remain silent for four minutes after detection while security is re-established.

Type: Time  
Scope: Per stream  
Strictest Requirement: 1 second  
Example Application: Audio conference - 10 seconds

### 3.2.9. Payment & Charging

#### Total Cost

The total cost of communication must be limited to this amount. This would be useful for transfer as opposed to stream type applications.

Type: Currency  
Meaning: Maximum charge allowed  
Scope: Per user per stream  
Strictest Requirement: Free  
Example Application: File Transfer: comms cost must be < 1p/Mb

#### Cost per Time

This is the cost per unit time. Some applications may not be able to predict the duration of a communication. It may be more meaningful for those to be able to specify price per time instead.

Type: Currency per timeS  
Scope: Per user per stream  
Strictest Requirement: Free  
Example Application: Video Conference - 15p / minute



## Cost per Mb

This is the cost per unit of data. Some communications may be charged by the amount of data transferred. Some applications may prefer to specify requirements in this way.

Type: Currency per data size  
Scope: Per user per stream  
Strictest Requirement: Free  
Example Application: Email advertising - 15p / Mb

## 4. Security Considerations

See comprehensive security section of taxonomy.

## 5. References

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