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P2P Streaming Protocol (PPSP) Requirements
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Abstract

   The objective of the PPSP work is to standardize the key signaling
   protocols that apply to tracker and peers in a Peer-to-Peer (P2P)
   streaming system. These protocols are called PPSP. This document
   enumerates the requirements for the PPSP, which should be considered
   when designing PPSP.

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1. Introduction

   Peer to Peer (P2P) computing has been successfully used in many
   fields, from one to one communication like Voice over IP (VoIP) and
   Instance Messaging (IM), to one to many communication like streaming,
   file sharing and gaming. In the streaming area, the popularity of
   P2P real-time and video on demand (VoD) streaming technology has been
   demonstrated by PPlive [WWW.PPLive], PPStream [WWW.PPStream], UUSee
   [WWW.UUSee], Pando [WWW.Pando] etc. Take PPLive for example, it has
   over 5 million online users at the same time for real-time streaming.
   Also some web2.0 streaming applications such as Youtube
   [WWW.YouTube], Tudou [WWW.Tudou] are reported to use or are preparing
   to use P2P engine to accelerate its downloading rate and cut down the
   transmission cost. P2P streaming applications account for more and
   more Internet traffic. According to statistics in a major Chinese
   Internet Service Provider (ISP), the traffic generated by P2P
   streaming applications exceeded 50% of the total backbone traffic
   during peak time in 2008. [PPSPPS]

   Given the increasing integration of P2P streaming into the global
   content delivery infrastructure, the lack of an open, standard P2P
   streaming protocol has become a major missing component in the
   Internet protocol stack. Multiple similar but proprietary P2P
   streaming protocols result in repetitious development efforts and
   lock-in effects. More importantly, it leads to substantial
   difficulties when integrating P2P streaming as a component of a
   global content delivery infrastructure. For example, proprietary P2P
   streaming protocols do not integrate well with infrastructure devices
   such as caches and other edge devices. [PPSPPS]

   The objective of the PPSP work is to standardize the key signaling
   protocols that apply to tracker and peers in a P2P streaming system.
   These protocols are called PPSP. PPSP will serve as an enabling
   technology, building on the development experiences of existing P2P
   streaming systems. Its design will allow it to integrate with IETF
   efforts on distributed resource location, traffic localization, and
   streaming control mechanisms. It allows effective integration with
   edge infrastructures such as cache and mobile edge equipment.
   [PPSPPS]

   This document enumerates the requirements for the PPSP, which should
   be considered when designing PPSP.

2. Terminology

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this

document are to be interpreted as described in RFC 2119 [RFC2119] and
indicate requirement levels for compliant implementations.

This document uses the following PPSP-related terms, which are
defined in [PPSPPS], including:

Chunk, Live streaming, Peer/PPSP peer, PPSP, Swarm, Tracker/PPSP
tracker, Video-on-demand (VoD).

Furthermore, the following additional terms will be used:

Peer list: A list of peer ID which are in a same swarm maintained by
the PPSP tracker. A peer must fetch the peer list of a swarm from
the tracker to know which peers have the required content.

Swarm ID: Identifier for certain swarm. It is used to describe a
specific resource shared among peers.

Usage type: Information used to identify the type of shared content.
Currently there are two usage types in PPSP: live streaming and VoD.
PPSP may also be extended to support more usage types, e.g. data
file.

Chunk ID: An identifier of a chunk for a certain resource which shows
the position (or time slot) of the chunk in the whole file (or live
streaming). A peer should report to tracker which chunks are
actively maintained in its buffer by sending the chunk IDs of a file
for certain swarm.

Buffer map: A map to indicate which chunks a peer currently has
buffered and can share with other peers. The buffer map can include
the offset (the ID of the first chunk stored by the peer), the length
of the buffer map, and a string of zeroes and ones indicating which
chunks are available. It reflects the content availability of a peer
in coarse grain.

```
            <------- Buffer Map Length ------------->
            +---+---+---+---+---+---+---+---+---+---+
 <---------->| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
    offset   +---+---+---+---+---+---+---+---+---+---+
 |------------------------------------------------------------------->
                                                    Content Length
```
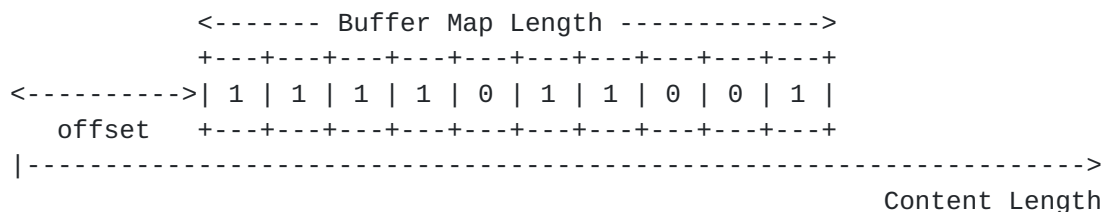
                    Figure 1: Buffer Map

Bitmap: A map of bits to reflect the availability of the smallest
transmission units in chunks. It can also be generally described as
content availability of a peer. Peers in a swarm need exchange the

bitmap information to know where to get their interested data units.

3. **Overview of PPSP**

   As described in [PPSPPS], the following components are considered in
   the scope of PPSP:

   1) Tracker communication. Tracker communication is a component that
   enables each peer to get peer list from the tracker and/or provide
   content availability to the tracker.

   2) Peer communication. Peer communication is a component that
   enables each peer to exchange content availability and request other
   peers for content.

   3) Report. Report is a component that enables peers to report
   streaming status to the tracker. The information may include swarm
   IDs to show swarms that the peer is taking active part in, chunk list
   for each swarm to show the current content availability in the peer,
   inbound/outbound traffic capacity, amount of neighbor peers, peer
   health degree and other streaming parameters.

   Therefore, PPSP includes the PPSP tracker protocol - a signaling
   protocol between PPSP trackers and PPSP peers, and the PPSP peer
   protocol - a signaling protocol among PPSP peers.

   PPSP tracker protocol will define:

   1) Standard format/encoding of information between PPSP peers and
   PPSP trackers, such as peer list, swarm ID, chunk information,content
   availability, streaming status including online time, link status,
   node capability and other streaming parameters.

   2) Standard messages between PPSP peers and PPSP trackers defining
   how PPSP peers report streaming status and request to PPSP trackers,
   as well as how PPSP trackers reply to the requests.

   PPSP peer protocol will define:

   1) Standard format/encoding of information among PPSP peers, such as
   chunk description.

   2) Standard messages among PPSP peers defining how PPSP peers
   advertise chunk availability to each other, as well as the signaling
   for requesting the chunks among PPSP peers.

   This document itemizes requirements for the following aspects of

PPSP:

1) Basic requirements to PPSP nodes (peer/tracker) and the content resource.

2) General requirements to the message format and process flow of PPSP tracker protocol.

3) General requirements to the message format and process flow of PPSP peer protocol.

4) Error handling and overload protection requirements.

5) Security requirements.

4. PPSP Requirements

4.1. Basic Requirements

In order to make PPSP work, some basic requirements must be satisfied, which are necessary preconditions for peers and trackers to take part in PPSP services and for content being shared among PPSP peers.

4.1.1. Basic Requirements to PPSP Node

PPSP.REQ-1: Each peer in PPSP MUST has a unique identifier, i.e. peer ID.

It's a basic requirement for a peer to have an identity in PPSP communication that other peers or tracker can refer the ID for the peer.

PPSP.REQ-2: The tracker in PPSP MUST have a public identity that can be discovered and accessed by PPSP peers.

It requires trackers are reachable with identifiers from Internet or other IP network. But how to discover the tracker is not in the scope of PPSP.

4.1.2. Basic Requirements to PPSP content resource

PPSP.REQ-3: The data resources shared in PPSP services MUST be classified and identified by different usage types.

PPSP is designed for P2P live streaming and VoD. It also has the potential to be used for P2P data file sharing. These usage types

have different requirements for truck queries and transmission
behaviors, e.g. data downloading order and time constraint.
Therefore, usage types are necessary to guide different content
sharing behaviors.

PPSP.REQ-4: The content in PPSP MUST be identified by swarm ID.

A swarm refers to a group of peers sharing the same content. It
could be a TV Channel, film name or file name. Swarm ID can be
looked as a resource ID to denote a specific content. The swarm ID
can be used in two cases: 1) a peer requests the tracker for the peer
list indexed by a swarm ID; 2) a peer tells the tracker about the
swarms it belongs to.

PPSP.REQ-5: The content resource shared by a swarm in PPSP MUST allow
being partitioned into chunks with a standard format.

A key characteristic of P2P streaming system is allowing the data
fetching from different peers concurrently. Therefore, the whole
content must be partitioned into small peaces, called chunks in PPSP,
for transmission. The chunks must be formed and sorted by a standard
way, so when a peer says it requires some chunks, e.g. 011, 012 and
013, other peers could understand which peaces wanted by the peer
exactly. Also, a normative buffer map can be used to show the chunk
availability of a peer.

PPSP.REQ-6: The content resource shared by a swarm in PPSP MUST have
a standard data format.

So, the availability of each data unit in a peer can be denoted in a
normative bitmap structure. By exchanging the bitmap, peers in a
swarm can schedule the transmission in the grain of the smallest data
units.

4.1.3. Other General Requriements

PPSP.REQ-7: The Tracker Protocol and Peer Protocol SHOULD enable
peers to receive streaming data within the time constraints required
by specific content items.

PPSP.REQ-8: The Tracker Protocol and Peer Protocol are Recommended to
be carried over TCP (or UDP, when delivery requirements cannot be met
by TCP).

4.2. PPSP Tracker Protocol Requirements

PPSP tracker protocol defines how PPSP peers report and request
information to/from PPSP trackers and how PPSP trackers reply to the

requests. The tracker discovery and the possible communication
between trackers are out of the scope of the PPSP tracker protocol.

PPSP.TP.REQ-1: The PPSP trackers MUST implement the PPSP tracker
protocol, for receiving PPSP tracker queries and periodical peer
status reports/updates from peers and for sending the corresponding
replies.

PPSP.TP.REQ-2: The PPSP peers MUST implement the PPSP tracker
protocol for sending PPSP tracker queries and periodical peer status
reports/updates to PPSP tracker and receiving the corresponding
replies from tracker.

PPSP.TP.REQ-3: The tracker request message MUST allow the peer to
solicit the peer list from tracker with the respect of the specific
swarm ID.

PPSP.TP.REQ-4: The tracker request message MAY include parameter of
requested number of downloading peers or preferred downloading
bandwidth.

PPSP.TP.REQ-5: The tracker reply message MUST allow the PPSP tracker
to offer list of active peers with the respect of the requested
swarm.

PPSP.TP.REQ-6: The peer status report (update) message MUST have the
ability to inform the tracker about the peer!_s activity with the
swarm and chunk information of the peer.

PPSP.TP.REQ-7: The PPSP tracker MAY generate the peer list with the
help of traffic optimization services, e.g. Alto.

PPSP.TP.REQ-8: The peer status report (update) message MAY have the
option to carry streaming status of the peer, including online time,
link status, peer capability and other streaming parameters of the
peer. Therefore, the tracker is able to select better candidate
peers for streaming without the help of other traffic optimization
services.

4.3. PPSP Peer Protocol Requirements

PPSP peer protocol defines how PPSP peers advertise data availability
and exchange neighbor peer information. The protocol will also
define the requests and responses of data chunks and peer properties
among PPSP peers. The transport mechanism and transmission control
are out of the scope.

PPSP.PP.REQ-1: The PPSP peers MUST implement the PPSP peer protocol

to exchange information and negotiate the data chunk requests and
responses before any content is transmitted.

PPSP.PP.REQ-2: The content availability request message MUST allow
the peer to solicit the chunk ID and bitmap information from other
peers with the respect of the peer list received from tracker.

PPSP.PP.REQ-3: The content availability reply message MUST allow the
PPSP peer to offer the list of chunk ID and bitmap of the data in its
buffer.

PPSP.PP.REQ-4: The content availability reply message MAY offer
information of other active peers than that in the peer list with the
same swarm ID and required chunks.

It is possible that a peer may need additional peers for certain
content. Therefore, it is allowed that the peer communicates with
the peers in the current peer list to obtain additional group of
peers in the swarm.

PPSP.PP.REQ-5: The content availability update message MUST be
advertised among swarm peers periodically or on-demand.

During the content transmission and the dynamic join/leave of peers,
the content availability information of neighborhoods are changing,
which requires being updated on time. A simple way to realize it is
advertising the chunk availability periodically among peers.
However, how often the advertisement is an open issue. Different
usage types may differ in the requirement. Too frequent updates
waste the network resource. Therefore, the update can be done on
demand. When a peer find there are not enough peers with certain
chunks, it will generate an update request to its neighbors to enrich
the peer list it maintains.

PPSP.PP.REQ-6: The peer streaming status update information MAY be
advertised among peers.

Streaming status information should be related to the content
delivery, including online time, link status, peer capability and
other streaming parameters of the peer. With this information, a
peer can select more appropriate peers for content sharing based on
some content sharing strategies and/or application requirements.

4.4. PPSP Error Handling and Overload Protection Requirements

PPSP.ERR.REQ-1: A peer MUST be able to respond with error information
to the peers sending PPSP messages, when some information (e.g. peer
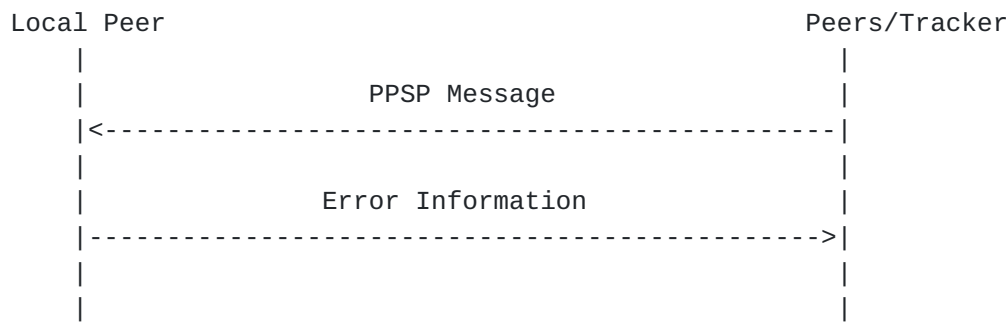list, chunk expression) cannot be understood in the message.

```
   Local Peer                                        Peers/Tracker
        |                                                 |
        |                     PPSP Message                |
        |<------------------------------------------------|
        |                                                 |
        |               Error Information                 |
        |------------------------------------------------>|
        |                                                 |
        |                                                 |
```

                        Figure 2: Error Handling

   PPSP.ERR.REQ-2: A PPSP tracker, which is operating close to its
   capacity limit, MUST be able to inform peers about its impending
   overload situation, and redirect them to another PPSP tracker.

   PPSP.ERR.REQ-3: A PPSP tracker, which is operating close to its
   capacity limit, MUST be able to inform peers about its impending
   overload situation, and terminate the conversation with the current
   PPSP tracker.

   PPSP.ERR.REQ-4: A PPSP tracker, which is operating close to its
   capacity limit, MUST be able to inform peers about its impending
   overload situation, and reject new conversation attempts.

5. Security Considerations

   The scope of this section is to analyze the security threats and
   provide the requirements for PPSP. While P2P streaming system
   prevails in recent years, an important but less studied problem is
   security.

   PPSP.SEC.REQ-1: PPSP MUST ensure that only authorized users can
   access the original media in the P2P streaming system. This can be
   achieved by defining or adopting such mechanisms as user
   authentication and/or key management scheme.

   PPSP.SEC.REQ-2: Confidentiality of the streaming data SHOULD be
   supported and the corresponding key management scheme MUST scale well
   without degrading the system performance.

   PPSP.SEC.REQ-3: PPSP MUST provide an option to encrypt data exchange
   among PPSP entities.

   PPSP.SEC.REQ-4: PPSP MUST prevent stream pollution attacks. In the
   stream pollution attack, the attacker mixes into the stream bogus
   chunks, or declare the chunks it doesn't have.

   Such an attack will degrade the quality of the rendered media at the
   receiver. For example, in a P2P live video streaming system a
   polluter can introduce corrupted chunks. Each receiver integrates
   into its playback stream the polluted chunks it receives from its
   other neighbors. Since the peers forwards chunks to other peers, the
   polluted content can potentially spread through much of the P2P
   streaming network.

   PPSP.SEC.REQ-5: PPSP MUST have mechanisms to limit potential damage
   caused by malfunctioning and badly behaving peers in the P2P
   streaming system. In addition there must be a way to identify badly
   behaving peers, and exclude or reject them from the P2P streaming
   system.

   PPSP.SEC.REQ-6: PPSP MUST prevent peers from exhausting the P2P
   streaming system's available resource, e.g. processing capacity,
   bandwidth, etc.

   Given the prevalence of DoS attacks in the Internet, it is important
   to realize that a similar threat could exist in a large-scale
   streaming system where attackers are capable of consuming a lot of
   resources with just a small amount of effort.

   PPSP.SEC.REQ-7: PPSP SHOULD minimize the dependency on reachability
   of centralized servers.

   PPSP.SEC.REQ-8: Existing security mechanisms SHOULD be re-used as
   much as possible in PPSP, to avoid developing new security
   mechanisms.

   PPSP.SEC.REQ-9: Security mechanisms of PPSP SHOULD not limit the
   scalability, performance and reliability of the P2P streaming system.

6. IANA Considerations

   This document presently raises no IANA considerations.

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