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An *Unified Multiplex Communication Architecture* for Simple Security Enhancements in IPv6 Communications

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Introduction

Current IP communication style is ***not optimized*** and has ***various problems***.
Sufficient **security considerations** (including privacy protection) are **not provided**.

e.g.,
It is known that:
"well-known port" method is **inappropriate** from security standpoint.
However, we still use it….
It is conventionally believed that:
"**one** node owns **one** IP address" and
"communication sessions are multiplexed at the transport layer basically."

We are moving to the IPv6 era:
it has become normal for **one** node to own **multiple** IP addresses.

It must be good time:
to reconsider the current communication style and
to establish a new communication architecture for security enhancements

Approaches to New Architecture

There are two types of approaches.

- Clean Slate type:
  - Redesign from scratch / Drastic change happens
  - Can NOT coexist with current
  - May require modifying existing applications
- **Coexist with current and Migrate type**:
  - Can coexist with current
  - Can use existing applications without modifying them

We choose Coexist with Current and Migrate type

Requirements to New Architecture

- **Anyone can use** it with ease.
  - **be simple enough (not complex)**
- Provide **sufficient security consideration**

But

- NOT modify current communication **Applications**
  - Applications should be used **as it is** now.
- NOT change end-users' **using convenience**

Analysis: Current IP sessions' Multiplexing and Service Providing Methods

The following **four** types of information

1: Destination **Port**	2: Source **Port**	(Transport Layer)
3: Destination **Address**	4: Source **Address**	(Network Layer)

and protocol information (TCP or UDP) are used
as a set for multiplexing and distinguishing IP sessions.

We call this **"Legacy Multiplex" method**

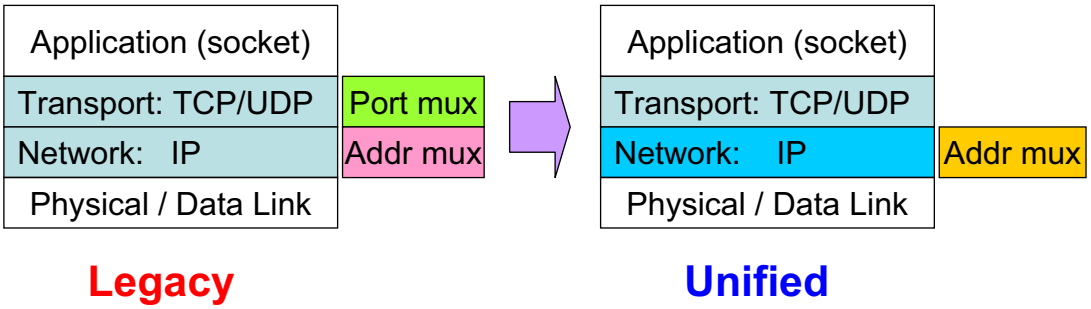
This method was invented in the IPv4 era:
when one node owned only one IP address.

The notion of a **Port** in the **Transport layer** was
introduced to multiplex the commutations sessions

Problems with **Legacy Multiplex method**

1. Sessions are distinguished by using **multi-layered** information
   - It is **NOT inevitable** to utilize **multi**-layered information to distinguish.
     (**single**-layered information may enough)
   - It is **inefficient** operations from function implementation viewpoint.
   - It is required for **intermediate nodes to parse Transport layer** info.
2. Service providing method using a "**well-known port**"
   - Port number information does **NOT stand for essential service**
   - **No** sufficient **privacy considerations** are provided
     - which services are provided by a server is found by any clients
3. Anycast / Multicast (non Unicast) Communication
   - Essence of the service is show **via IP address** information.
   - Port number information is less significant (almost ignored)

Proposal: **Unified Multiplex** Communication Architecture as a Solution



- Sessions' multiplex / distinguish operations is simplified:
  can be done **only on the single Network Layer**
- Necessary information for the operations is simplified:
  Destination and Source IP address information only

1: Destination **Address**	2: Source **Address**	(Network Layer)

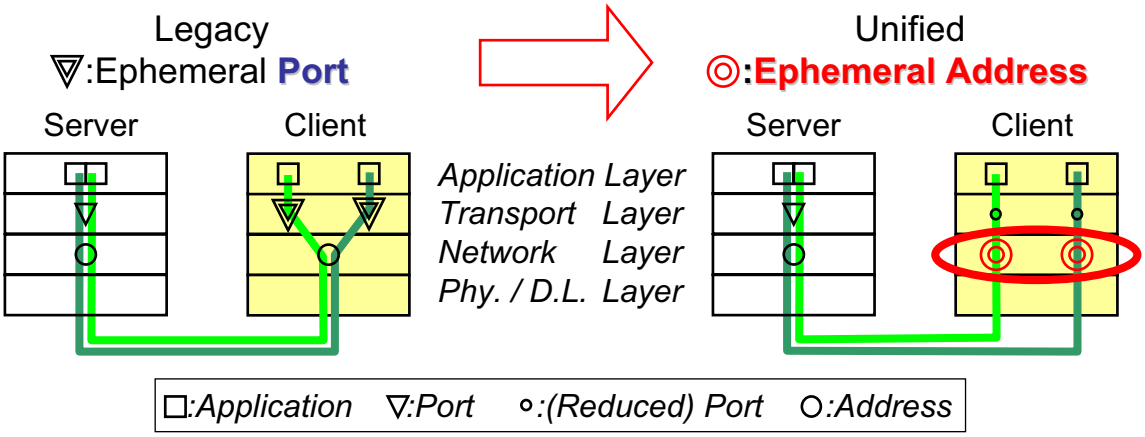
Two types of newly introduced Session Specific IP addresses

If sessions are different,
used addresses in the sessions are **different**.
Used Address becomes **specific for each session**.

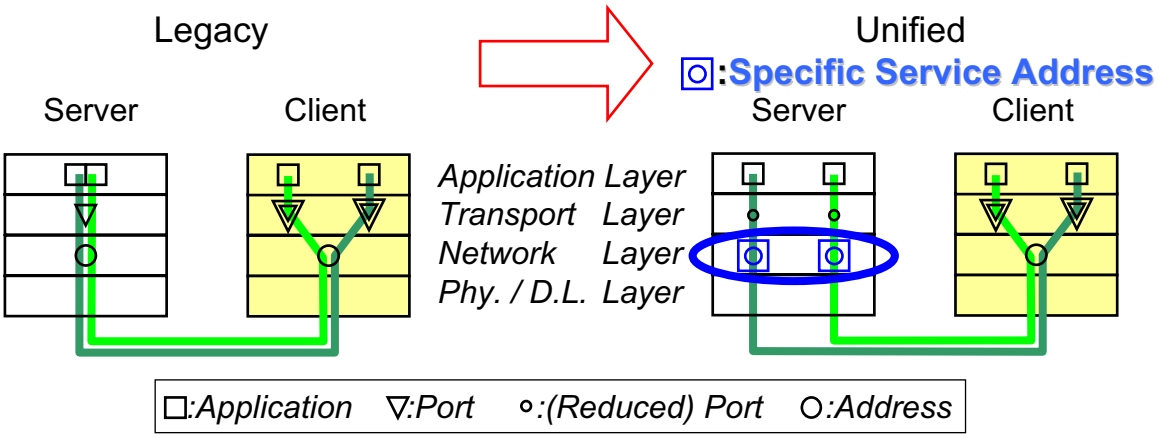
- Client Side:
  - **EA (Ephemeral Address)**
- Server Side:
  - **SSA (Specific Service Address)**

Addresses are dynamically ***Generated*** and ***Released***
when their sessions are ***Started*** and ***Ended***.
Address valid time period is limited

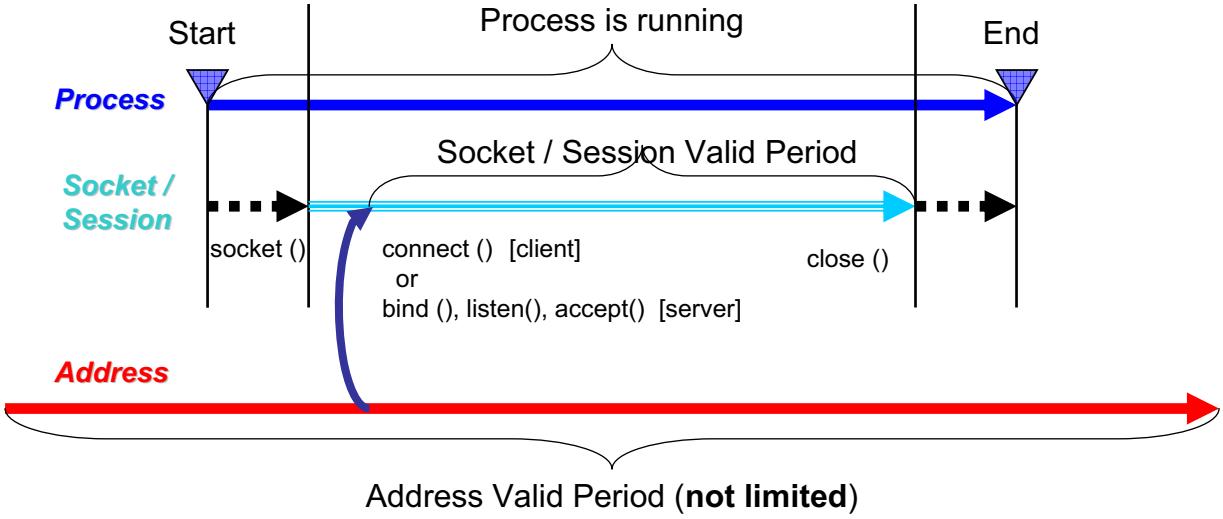
EA (Ephemeral Address) at Client Side from layer structure viewpoint



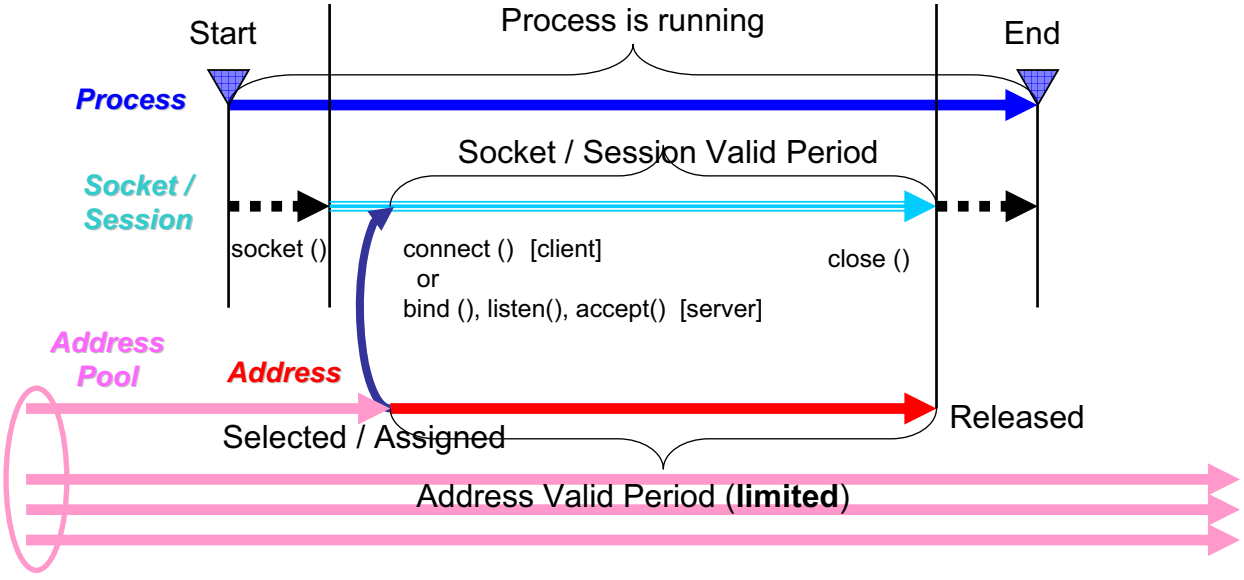
SSA (Specific Service Address) at Server Side from layer structure viewpoint



Relationship between Process and Address
Legacy Environment



Relationship between Process and Specific Address
Unified Multiplex Environment



Address Pool function is introduced

Improvements in Address Usages, Service Providing Methods etc.

1 Node-1 Fixed Address ⇒ 1 Node - Multi-Floating Address

	Legacy →	(Proposed) **Unified**
Number of Used Addresses	Use Only **One** Address (Basically)	Use **Multiple** Addresses
Information Dealing	General and **Share** Use **Same** Address	Specific and **Dedicated** Use **Different** Address
Service (on Servers)	Wait for **Anytime** (24hour / 365days)	Wait for **Only When** Access Expected to Come
Information Fluidity	**Fixed** (Not Changed)	**Floating (Changed** and **Updated)**

Quantitative Analysis: "Meet Again" Probability for the **same** Address

Condition:

Ephemeral Address Creation/Selection Rule is:

"***At Random***" from 64bit Interface ID space.

Probability Formula (Birthday Paradox):

"***n***" times probability:

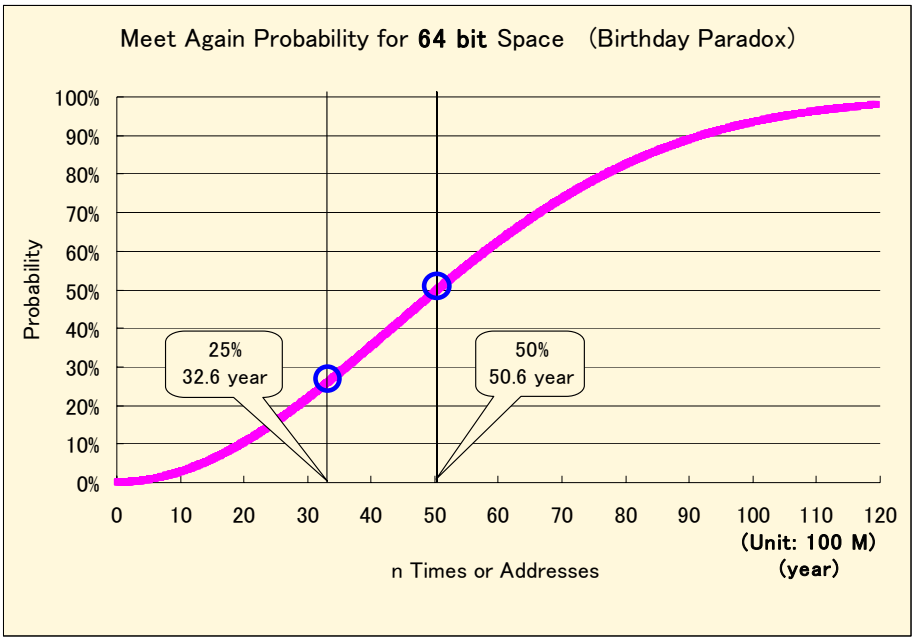
$= 1 - (2^{64}-1)/2^{64} * (2^{64}-2)/2^{64} * \ldots * (2^{64}-\boldsymbol{n})/2^{64}$

Estimation: Number of ***consumed addresses*** per (year, day, hour, min, sec)

/ year	/ day	/ hour	/ min	/ sec
31,536,000	86,400	3,600	60	1.0
100,000,000	273,973	11,416	190	3.2

"100M addr. / year" is much enough (***sufficient estimation***)

"Meet Again" Probability Results for the **same** IP Address



Consume 100M addr. / year (274k addr./day : 3.2 addr./sec)

10years: 2.8% 20years: 10.3%

25%: 32.6 years **50%: 50.6 years** 75%: 71.6 years

Characteristics of Specific Addresses (EA and SSA) introduced in the Unified Multiplex

- Client side: **EA (Ephemeral Address)**
  - Any users can use **Ephemeral Address** easily
  - It is not necessary for users to be conscious the existence of **Ephemeral Address** function (like Ephemeral Port).

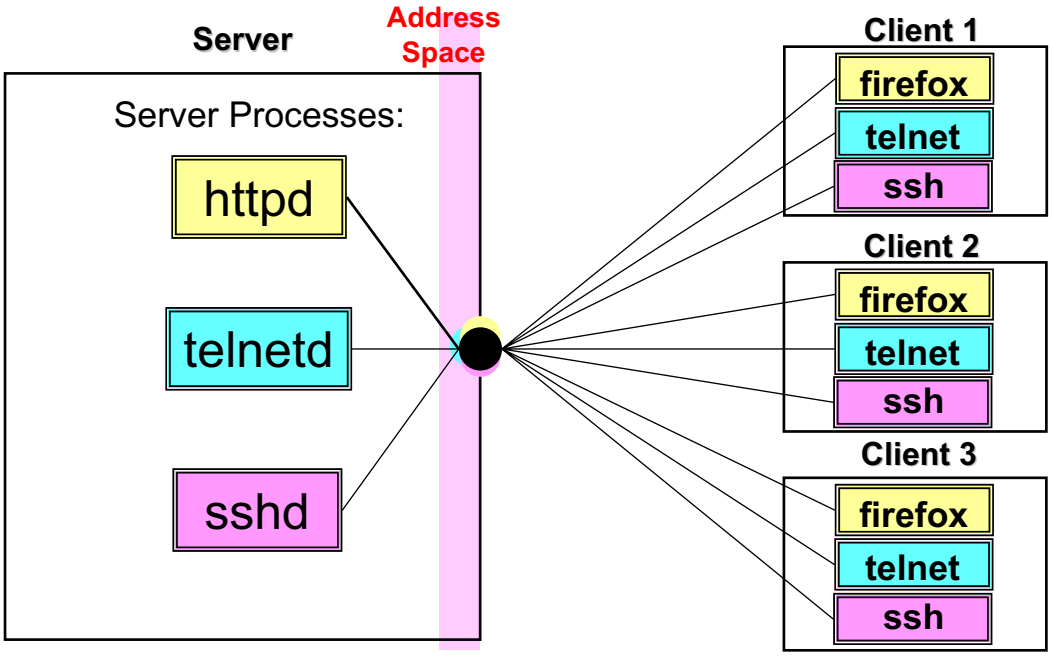
  Very low threshold to deploy and use this

- Server side: **SSA (Specific Service Address)**
  - Completely newly invented functions and **very unique**
  - No analogical functions can be found in the Legacy method

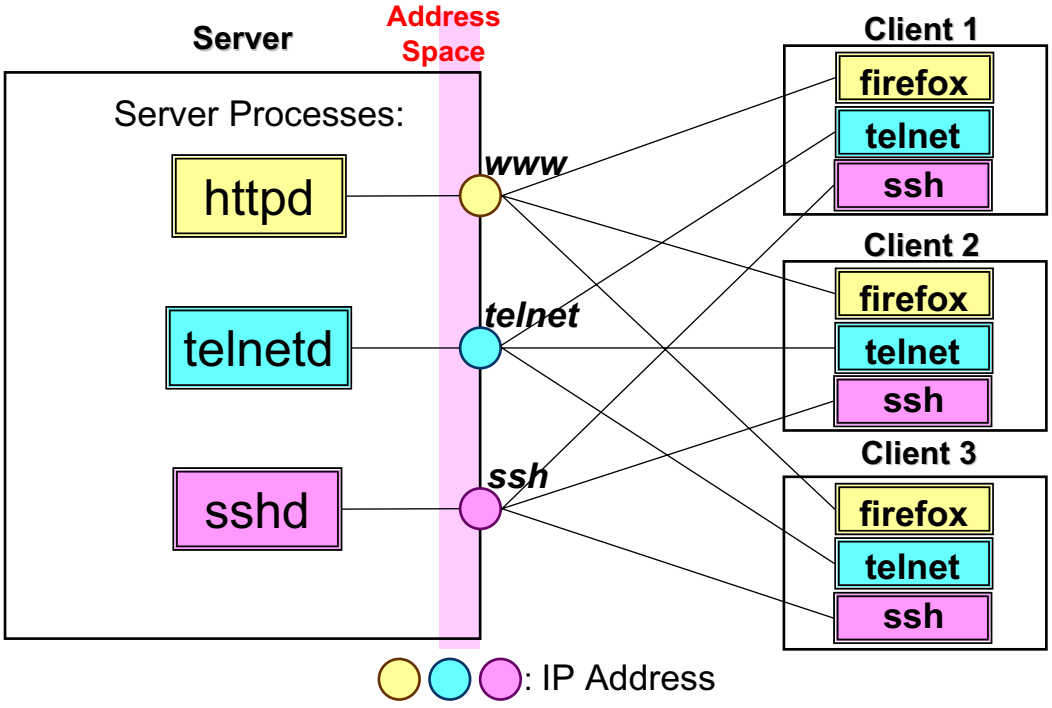
  Further researches are required to fully utilize this

Hereafter, SSA issues are disccused

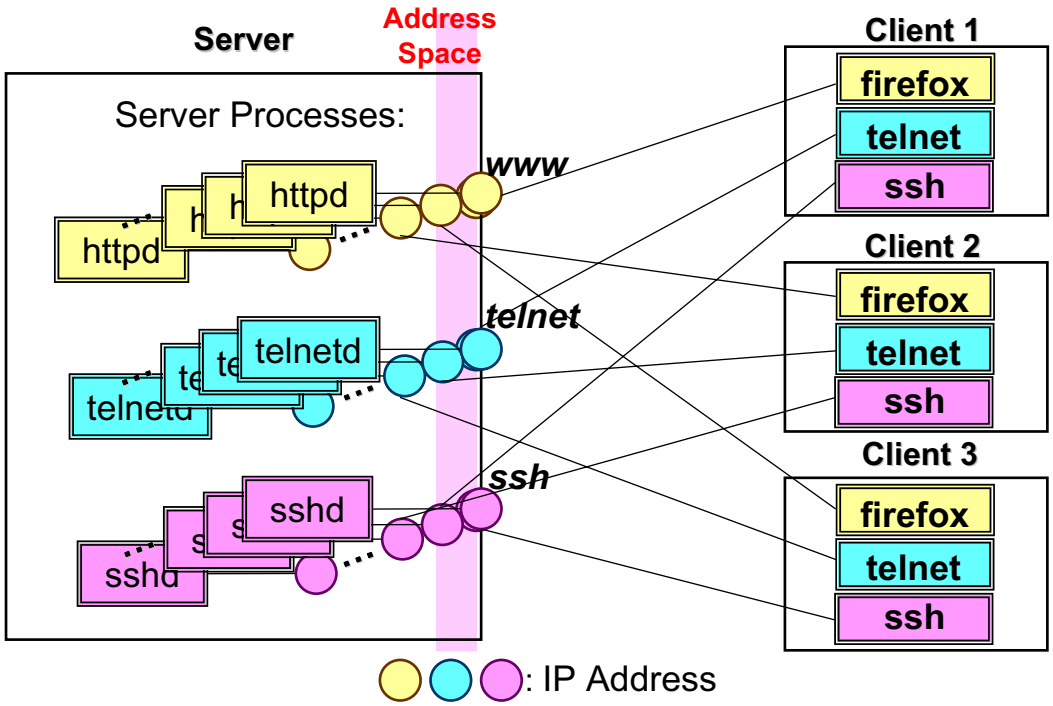
IP Address Using Style:
Legacy Multiplex Environment



IP Address Using Style:
Transient Environment until SSA



IP Address Using Style:
Unified Multiplex Environment with SSA



Implementation and Verification Status

Unified Multiplex Communication Architecture
functions have been implemented on the followings.

- FreeBSD 6.2R FreeBSD 8.0R
- Linux kernel 2.6.24 (implemented functions are limited)

➢Without modifications of communication Applications:
➢Only **with** the **Kernel replacement**:

It has verified that
basic functions work correctly as they are designed

Conclusion

We have proposed:
an new communication architecture "**Unified Multiplex**"
and new address types (**EA** and **SSA**).
- This can coexist with current communication style.
- Anyone can use this with ease.

It have been proved:
this is an ***advanced communication architecture***
that can provide ***sufficient security consideration***.
- No fatal problems have not observed until now.
- Veiled problems may be remained

We will continue refining the design and implementation
and evaluating the architecture by utilizing
its functions on various communication applications.