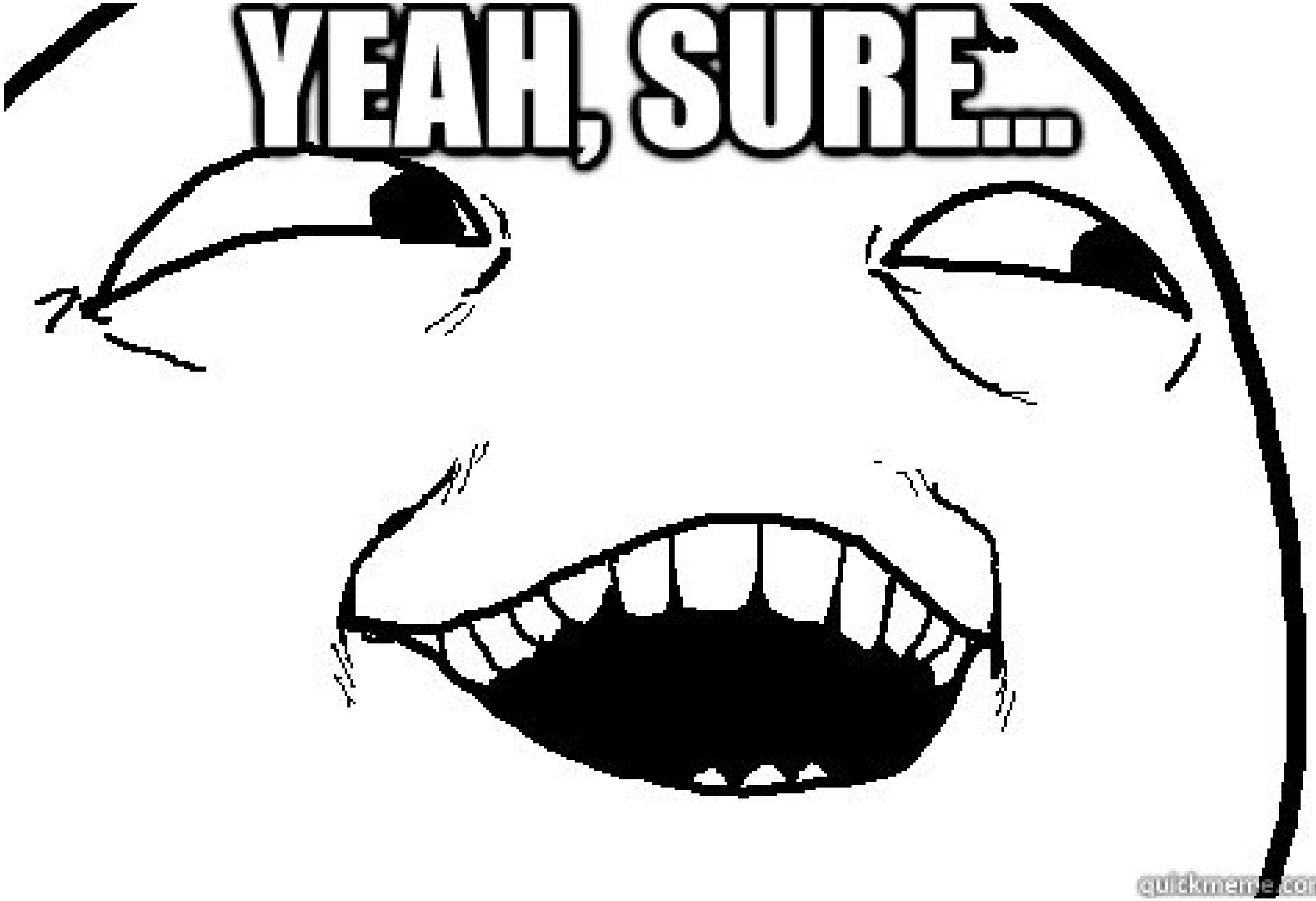
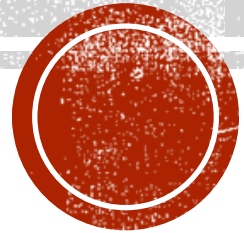
Developer: I'm so glad I'm not a Networks Engineer and I don't have to worry about IPv6!


YEAH, SURE...
quickmeme.com

PREPARING APPS FOR IPV6

A SOFTWARE DEVELOPERS GUIDE TO WRITING AND MIGRATING NETWORKED APPLICATIONS FOR USE ON IPV6 NETWORKS[1]



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- **Who am I?** I ask it myself every morning ☺
  - I used to work for LACNIC
  - Doing a Master's in University Carlos III of Madrid now
- **Why am I here?** I wanted to come to Zurich and needed an excuse ☺
  - IPv4 is dead
  - Network engineers are aware of this
  - But what happens at higher layers? Is it really transparent for them?
- **Who else should be here?**
  - Software architects, developers, engineers, etc.; computer programmers; any other curious person.
- **What is this presentation for?**
  - *Developers*: Checklist of areas to investigate in your software's code
  - *Users*: Inform yourself about the issues your software may encounter with an IPv6 deployment.

WHAT AM I GOING TO DELIGHT YOU WITH?

- **Strategies for apps supporting both IPv4 and IPv6**
- **Sockets**
- **Proxy and Application Servers**
- **Format and Comparison**
- **Persistence and Databases**
- **URIs/URLs**
- **IP Geolocation**
- **Address Types and Special Addresses**
- **Infrastructure Connectivity**
- **DNS Considerations**
- **Miscellaneous “Gotchas”**

STRATEGIES FOR IPV6-READY APPS

- IPv6-only app or add IPv6 support to current app?
- IPv6-only (Multiple versions of your app)
  - Users may find it difficult to know which version to use (IPvWhat?)
  - Maintain two versions of almost the same source code
  - *Possible Solutions*:
    - Hybrid app
    - Wrapper app -> Will probably be too complex
- So? Probably the best option is add IPv6 support to the current app and have an **hybrid app.**
- Or… become a chef and forget about all this ☺

SCENARIOS

- **Best-case scenario** -> IPv4/IPv6 app on dual-stack platform
- **Not-so-good scenario** -> IPv6-only app on dual-stack
- **Another scenario** -> IPv4/IPv6 app in IPv4-only system

- Check 'RFC 4038 - Application Aspects of IPv6 Transition '
  - https://tools.ietf.org/html/rfc4038

SCENARIOS (CONT.)

- **IPv6-only app on dual-stack device**
  - App will be IPv6-only and won't work in IPv4-only platforms
  - *IPv4-mapped* IPv6 addresses (::FFFF:x.y.z.w) would allow app to interoperate with both IPv4 and IPv6 nodes
  - **Be careful!!** Internal IPv4-mapped addresses may be disabled by default due to security concerns (bypass of IPv4 filters)
- **IPv4/IPv6 app in IPv4-only system**
  - App has to handle the case of IPv6 not being available

SOCKETS

- Changes to app will depend on the programming language being used
- Two categories for changes:
  - 1) hostname lookups
  - 2) generalization of the socket calls to accommodate both IPv4 and IPv6
- Check if calls are IP version-agnostic
- Change AF_INET to AF_ INET6 if necessary
- May need to change bind address to "::"
- More details in Guide[1]

PROXY AND APPLICATION SERVERS

- Socket mgmt may be delegated to proxy and application server software and frameworks.
- **BUT** server framework has to be set up to listen on an IPv6 port (simple task but don't forget to do it!)
- Verify IPv6 support was specified during compilation. E.g. PHP and nginx
- JVM-based servers -> runtime property "java.net.preferIPv4Stack" FALSE by default
  - **BUT** many application servers such as JBoss AS / WildFly set the value to TRUE in their startup scripts.

FORMAT AND COMPARISON

- Leading zeros can be omitted both in IPv4 and in IPv6
- **BUT** three different formats for IPv6 addresses (full, compressed, and IPv4-embedded)
- **And it gets better!** An IPv6 address can be compressed and also have an embedded IPv4 address, and the hexadecimal characters can be either in upper or lower case
- So… string comparisons are practically impossible in IPv6 ☹
- *Regular expressions*: simple for IPv4 **but** very bad performance for IPv6
- *Numeric expressions*: IPv4 addresses -> unsigned 32-bit integer (optimizes both storage and comparison) **but** many platforms do not have a 128-bit integer data type

FORMAT AND COMPARISON (CONT.)

- So? What can we do?
  - Lower 64 bits of IPv6 addresses -> end-site
  - Upper 64 bits -> to route Internet packets to and from the end-site.
  - => Depending on how the IP address is used, the application may drop part of the address.

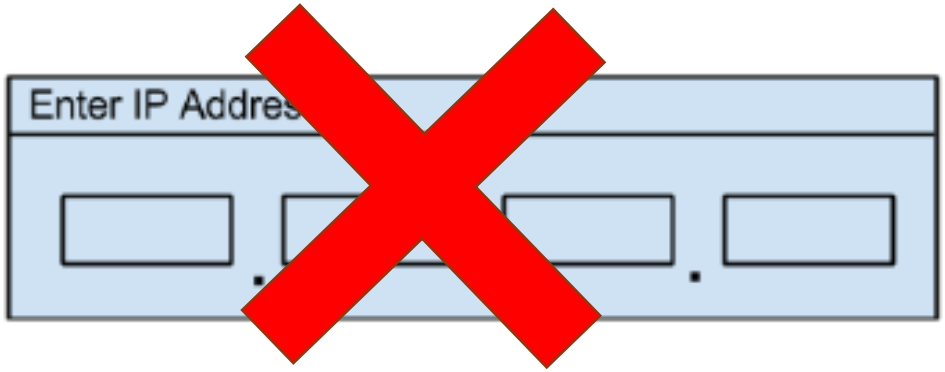
- **BUT** it could get even more interesting!
  - 64-bit numeric value defined as a floating-point data type
  - Most of which offer 57 bits of precision
  - Possible 'hack': Analyse current public IPv6 space issued by IANA to RIRs
    - Addresses start with: 2001, 2002, 2003, 2400, 2600, 2610, 2620, 2800, 2A00 and 2C00
    - 10 bit patterns that could be enumerated into a 4-bit field
    - Reduction from 16 to 4 bits, 64-bits prefixes could be represented with only 52 bits

FORMAT AND COMPARISON (CONT.)

- **BCP** -> use tailored library
  - IPAddr in Ruby; *IPy* or built-in *ipaddress* in Python; *Net::IP* and *NetAddr::IP* in Perl, PEAR's *Net_IPv4* and *Net_IPv6* classes in PHP; built-in *InetAddress* classes in Java
- These libraries also resolve issues surrounding textual presentation and textual validation that are important with UIs.
- **IETF guidance** regarding the presentation of IPv6 addresses in text form[2]
  1. Do not display leading zeros
  2. Use the :: notation when possible but only on the last series of zero bytes and never for just one
  3. Lowercase the hexadecimal characters

FORMAT AND COMPARISON (CONT.)

- Length of IPv6 addresses is unpredictable.
- Some could be too long to be included in messages.
  - Non-essential parts could be hidden
- User input of IP addresses
  - Do not use separate text boxes
  - Offer one text area -> Users ♡ cut & paste



PERSISTENCE AND DATABASES

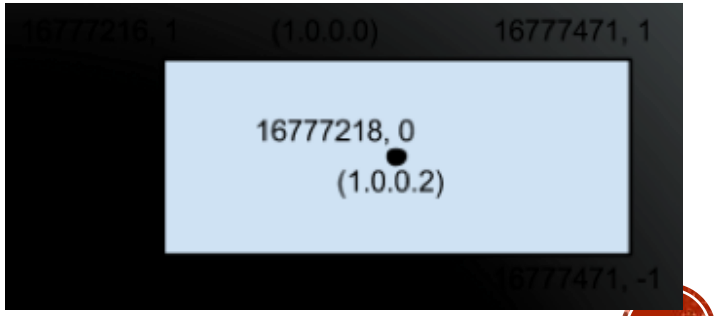
- For logging source IP addresses, tracking user logins, creation of whitelists, etc.
- How much storage space is needed to persist IPv6 addresses?
- *Strings:* VARCHAR(45) instead of VARCHAR(15)
- *Binary:* 16 bytes instead of 4 bytes

PERSISTENCE AND DATABASES (CONT.)

- **MySQL**
  - *BIGINT* is not enough but could be used if part of the IP address can be dropped
  - Use *Spatial extensions* to determine if an IP address falls within a certain range (as B-tree indexes do not perform well)
    - IP networks are modelled as rectangles and R-tree indexes are used

      (Much better performance ☺ Yay!)
  - INET6_ATON and INET6_NTOA instead of

    INET_ATON and INET_NTOA functions



PERSISTENCE AND DATABASES (CONT.)

- **PostgreSQL**
  - Since PostgreSQL 7.4 (2003) -> built-in datatypes *inet* and *cidr*, both capable of representing IPv6 addresses.
  - *IP4r* built extension, which leverages PostgreSQL's GiST extensible indexing feature (also uses R-Tree indexes)
- **Oracle**
  - NUMBER data type unusable for IPv6 (it can represent at most 38 significant digits)
  - Also has GIS extensions but they use NUMBER as the base type
  - Solutions:
    1. Store them as a string of characters
    2. Drop some of the lower-order bits and represent high-order bits by NUMBER

URIS / URLS

- E.g., for RESTful communication to server-based applications
- *Basic syntax of all URLs*: [scheme]://[host]:[port]/[path][query]
- **In IPv6**: Need to escape ':' by square brackets ('[' and ']')

  https://[2001:500:4:13::125]:443/

- **Care needs to be taken when constructing URLs!!**
  - IPv6 may cause errors in the host portion of the URI.
  - Code may need to check if the host is an IPv6 address and, if so, escape it.
  - (you can find examples in the Guide[1])

IP GEOLOCATION

- Geolocation of client based on client's IP address
- Depending on **IP geolocation database**, IPv6 may not be supported

ADDRESS TYPES AND SPECIAL ADDRESSES

- **Loopback** address (localhost) -> to connect to other processes on the same node (IP sockets)
  - IPv4 -> between 127.0.0.0 and 127.255.255.255 (usually 127.0.0.1)
  - IPv6 -> only one loopback address, ::1
- Clients should resolve the "localhost" hostname instead of using an IP address.
- Servers should use IP address libraries if available
  - Ruby, Java, Python and other languages, are dependent on the underlying operating system to map "localhost" to a loopback address ('localhost6' in some OSs)

ADDRESS TYPES AND SPECIAL ADDRESSES (CONT.)

- IPv6 has **multicast** instead of broadcast
- Portable code -> use multicast both for IPv4 and for IPv6
- All nodes on a local network -> 224.0.0.1 and ff02::1(no portable way to address both IPv4 and IPv6 multicast nodes with a single address)
- Dual-stack nodes will receive duplicated data **so** tags should be used
- Check *IANA IPv6 Multicast Address Registry*[3] to determine appropriate IPv6 multicast address when porting functionality from IPv4

ADDRESS TYPES AND SPECIAL ADDRESSES (CONT.)

- **IPv4-compatible IPv6 addresses** (::192.168.0.1/96) (DEPRECATED) and **IPv4-mapped IPv6 addresses** (::ffff:192.168.0.1/96)
- **Be careful!**
  - Multiple representations possible
  - Different behaviours for different languages.

```
InetAddress i =
InetAddress.getByName(address );
System.out.printf( "%20s = %s\n"
,address, i.getHostAddress() );
192.168.0.1 = 192.168.0.1
::192.168.0.1 = 0:0:0:0:0:0:c0a8:1
::c0a8:1 = 0:0:0:0:0:0:c0a8:1
::ffff:192.168.0.1 = 192.168.0.1
::ffff:c0a8:1 = 192.168.0.1
```

- **Link-local addresses** -> only valid in the local network
- **Be careful!**
  - Link-local addresses are not routable

INFRASTRUCTURE CONNECTIVITY

- C-S and S-S connections must be considered
- **Enable IPv6 in the OS** -> Not always enabled by default
  - Set up interfaces (use static addresses!!)
  - How? Highly dependent on OS/distribution
  - **Be careful** with Windows servers! Microsoft's Teredo service has been deprecated.
- **Firewalls/Filtering**
  - Probably two or more levels of filtering (local, network firewall, border firewall)
  - Allow traffic to/from app port (both in IPv4 **and** in IPv6)
  - ICMPv6 is **essential** for IPv6 to work properly (E.g. ND) and for troubleshooting (E.g. Echo request/reply) (See RFC 4890[4])
  - Allow traffic to/from multicast and link-local addresses
  - *Recommendation*: flexible local firewall; more filters at network/border firewall

DNS CONSIDERATIONS

- Protocol used to carry DNS query vs protocol about which we are asking
- If app will be accessed remotely -> add (or ask sysadmin to add) IPv6 info to app server name
  - AAAA to translate name into IPv6 address
  - A single hostname can have A records **and** AAAA records

```
example.com. IN A 192.168.1.10
example.com. IN AAAA 2001:db8:1:1::10
```

- If app will access other services by name -> make sure it queries both A and AAAA records
  - Being able to translate a hostname into an IPv6 address doesn't mean that the server application supports IPv6 -> client app may fail to establish connection
  - *Solution:* client app should request all IP addresses and try until a working address is found (default version or runtime decision) (E.g. Happy eyeballs[5])

DNS CONSIDERATIONS (CONT.)

- When **translating** names <-> addresses:
  - Make sure you use functions that support IPv6
  - Set preference (prefer IPv4 or IPv6?)

MISCELLANEOUS 'GOTCHAS'

- **Apps that rely on CDNs**
  - Does the CDN serve content over IPv6? If it doesn't how will the content be proxied between its IPv4 servers and your IPv6 customer?
  - Have AAAA DNS records been provisioned for serving CDN data to IPv6 clients?
- Apps that publish **APIs** or use APIs in which an API call takes an IP address as a parameter
  - Check that the parameter can be passed as either an IPv4 address or an IPv6 address

MISCELLANEOUS 'GOTCHAS' (CONT.)

- **Virtual Machines and System Containers and Clouds**
  - Check whether host and any virtual machines hosted within support IPv6
- **The Obvious But Overlooked**
  - Config files and other config data
  - Monitoring and alert systems
  - Log analyzers and analytic engines
- **Documentation**
  - Include IPv6 addresses in documentation for software (Use prefix 2001:db8::/32)

Supporting IPv6-only Networks

May 4, 2016

At WWDC 2015 we announced the transition to IPv6-only network services in iOS 9. Starting June 1, 2016 all apps submitted to the App Store must support IPv6-only networking. Most apps will not require any changes because IPv6 is already supported by NSURLSession and CFNetwork APIs.

If your app uses IPv4-specific APIs or hard-coded IP addresses, you will need to make some changes. Learn how to ensure compatibility by reading Supporting IPv6 DNS64/NAT64 Networks and watch Your App and Next Generation Networks.

< Back to News

REFERENCES

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3. http://www.iana.org/assignments/ipv6-multicast-addresses/ipv6-multicast-addresses.xhtml
4. http://www.ietf.org/rfc/rfc4890.txt
5. https://tools.ietf.org/html/rfc6555

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KEEP CALM AND DEPLOY IPv6


NO QUESTIONS?
GREAT!!
I'M GLAD I WAS SO CLEAR!