# JmDNS : Service Discovery for the 21st Century

Brian Sletten
Bosatsu Consulting, Inc
brian@bosatsu.net

NoFluffJustStuff
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# Speaker Qualifications

- 12 years of software development experience
- Have own software consulting company for design, mentoring, training and development
- Work with Semantic Web, Aspect-Oriented Programming, Grid Computing

# Agenda

- Where We Have Been
- ZeroConf
- Bonjour
- JmDNS
- Brainstorming

# Where have we been?

# FINDING THINGS IN THE PAST

- Configuration Files (ick!)
- DNS (requires central authority, hostname only -- no ports)
- Directory Services
- AppleTalk (chatty “has been”)
- JINI (Java-only, central services)
- JXTA (steep learning curve)

# AD HOC NETWORKING TOO HARD

- Law Offices, Schools, etc. do not always have sufficient IT personnel
- Home networking is even worse!
  - Could your grandma set up a DNS server?
  - LDAP at home?
- What is so hard about two devices talking?

# Protocol Design Goals

- Internet Protocol (IP) was designed to be interoperable, extensible and scalable
- Propietary protocols (AppleTalk, NetBIOS/SMB, IPX) were designed around local network features and decentralized discovery

# AppleTalk

- Ahead of its time -- focused on services, not devices
- Too chatty for large networks
- Not based on IP
- Support persists but waned with Apple's pre-OS X fortunes

# DHCP

- Solves some of the problem
  - Dynamic address allocation
  - Great for clients
    - Client-Server sessions are easy to regenerate
  - Not-so-great for servers

# DHCP (Cont)

- However, still focuses on hardware, not services (i.e. capabilities)
    - Users care about 'printing' and 'sharing files' and listening to 'music'
    - How to publish? find? bind?

# JINI

- Showed a lot of early promise for finding devices and services on a network
- Problems:
  - Required Java (harder to embed on devices, at least historically)
  - Required Central Services
  - Tried to proscribe service hierarchies

# JXTA

- Bill Joy Brain-Sibling to JINI
- Multi-language/Multi-Platform
- Huge Learning Curve
- Although it has languished, good things might still come from the JXTA world

# Publish/Find/Bind

- Hmmm… sounds familiar
- WebServices are hoping to solve some of these problems
  - UDDI/WSDL/SOAP
  - We'll get back to you once WS-Whatever Draft is completed

# ZeroConf

# Zeroconf History

- Began out of discussions on a mailing list in 1997
- Interested people got together at IETF BOFs
- ZeroConf WG was formed in 1999

# Zeroconf Goals

- Allocate addresses without a DHCP Server
- Translate names and IP addresses without a DNS Server
- Find services without a directory server
- Reuse existing technologies, infrastructure and expertise

# Zeroconf Technologies

- IPv4 Link-Local Addressing
- Multicast DNS
- DNS Service Discovery

# IPv4 link-local Addressing

- Uses `169.254/16` prefix for “local links”
  - Between 169.254.1.0-169.254.254.255
  - Reserved by IANA for this purpose
- Links are local when
  - Host A sends a packet that arrives unmodified (i.e. no TTL decrements)

# IPv4 link-local Addressing (cont)

- Hosts should not use “link-local” and routable addresses at the same time
  - Will use an IP address from DHCP if one is available

# IPv4 Link-Local Process

- Generate an address using a PRNG (preferably seeded w/ MAC address or something uniqueish)
- ARP Probe for conflict
- Claim address on success
- Defend address on future conflict (ARP)
    - Must relinquish if conflict persists

# MULTICAST DNS

- Designed to allow naming lookups without central server
- Introduces `.local` domain
  - DNS is IETF technology so they are responsible, not ICANN

# Multicast DNS (Cont)

- Queries are sent to `224.0.0.251` on port `5353`
- Uses multicast broadcasts but is well-designed to minimize chattiness
  - Hosts listen to changes and can cache results
  - To avoid pig-piling new queries, mDNS responders delay responses by random value to see if someone else will respond

# Query Types

- One Shot
  - “Just give me something”
- One Shot - Accumulate Results
  - “Stick around for multiple results”
- Continuous Query
  - “Keep on keepin’ on”

# Avoiding Chattiness

- Known Answer Suppression
- Passive Caching/Listening
- Exponential Decay Rates
- TTL Expirations
- New peers announce themselves

# Claiming the Name

- Pick a name (user-specified?)
- Put together a DNS A Record
- Perform T_ANY query to find any other records with same name
- Upon success (no conflicts), announce to the world who you are

# Clients and Services

- Users care about relevant services not all that are available
    - Printer around the corner
    - My wife's Excellent iTunes Music Collection
    - SSH into development server

# DNS SERVICE DISCOVERY (DNS-SD)

- No changes to DNS structures
- Use DNS PTR queries to find SRV records that match service instance pattern

```
<instance>._protoname._transport.<domain>
```

- Use TXT records for parameters

# DNS-SD Goals

- Service Instance Enumeration
- Service Name Resolution
- Somewhat persistent
  - Here today, here tomorrow
- Simple to implement

# DNS-SD Service Instance

- Browsing Service Instances
  - "Leaves in a tree"
    - <domain>.<service>.<instance>
  - Name compression in responses

# DNS-SD Txt Records

- Up to 65535 bytes
- Packed representation of zero or more strings

# DNS-SD TXT Records (Cont)

- `Name=Value` Pairs
  - Not present
  - No value (“`Debug`”)
  - Empty value (“`Debug=`”)
  - Non-Empty value (“`Debug=verbose`”)

# DNS-SD Query Example

- `_ftp._tcp.example.org`
- `_http._tcp.example.org`
- `_ipp._tcp.example.org`
- `_daap._tcp.Carini.local`
- `_tivo_servemedia._tcp.Carini.local`

# DNS-SD Meta-Query

- `_services._dns-sd._udp.<domain>`
  - Returns a list of PTR records matching service type

# Registered DNS-SD Services

- http://www.dns-sd.org/ServiceTypes.html

| | | |
|---|---|---|
| MYOB | Adobe | Axis Video Cameras |
| Bootstrap Protocol Server | Oracle Cluster Topology Server | CodeWarrior |
| Elgato EyeHome | ebXML Messaging/Registry | FAXstf |
| Roxio ToastAnywhere | H.323 A/V Communication Setup Protocol | SubEthaEdit |
| Kerberos Administration | LDAP | NFS |
| Network Time Protocol | PostgreSQL Server | JINI Servicees |
| PowerEasy POS | Session Initiation Protocol | Skype |
| SliMP3 Server Interfaces | Sun Grid Engine | Sybase Server |

# Bonjour
# (aka Rendezvous)
# (aka Opentalk)

# Bonjour

- History
- Open Source
- Apple's Use of Bonjour
- Products
- Tools

# History

- AppleTalk released initially in mid-80's
- Very popular on smallish networks
- Part of what made Macs 'just work'
- Apple wanted to replace functionality with protocol that fits in modern networks (i.e. IP-based)

# Open Source

- Apple wants to encourage the use of Bonjour so it open sourced it
- Includes support for OS X, Windows, Windows CE, Linux, VxWorks
- http://developer.apple.com/networking/bonjour

# Apple's use of Bonjour

| Name | Service |
|---|---|
| AppleTalk Filing Protocol (AFP) | _afpovertcp._tcp |
| Network File System (NFS) | _nfs._tcp |
| WebDAV File System (WEBDAV) | _webdav._tcp |
| File Transfer Protocol (FTP) | _ftp._tcp |
| Secure Shell (SSH) | _ssh._tcp |
| Remote AppleEvents | _eppc._tcp |
| Hypertext Transfer Protocol (HTTP) | _http._tcp |
| Trivial File Transfer Protocol (TFTP) | _tftp._udp |
| Remote Login (TELNET) | _telnet._tcp |
| Remote Audio Output Protocol (RAOP) | _raop._tcp |

| Name | Service |
|---|---|
| Line Printer Daemon (LPD/LPR) | _printer._tcp |
| Internet Printing Protocol (IPP) | _ipp._tcp |
| PDL Data Stream (Port 9100) | _pdl-datastream._tcp |
| Remote I/O USB Printer Protocol | _riousbprint._tcp |
| Digital Audio Access Protocol (DAAP) | _daap._tcp |
| Digital Photo Access Protocol (DPAP) | _dpap._tcp |
| iChat Instant Messaging Protocol | _presence._tcp |
| Airport Base Station | _airport._tcp |
| Xserver RAID | _xserveraid._tcp |
| Apple Remote Desktop (ARD) | _net-assistant._tcp |

# PRODUCTS

- TiVo, Asterisk VOIP PBX
- Printers (HP, Brother, Epson, Xerox, Lexmark, Canon)
- SubEthaEdit, Growl
- Axis Network Cameras
- Oracle, Roxio Toast Anywhere

# Bonjour Browser Demo

# JmDNS

# JmDNS

- Open Source project started by Arthur van Hoff while at Strangeberry

- Renamed from JRendezvous for legal reasons, moved to SourceForge and taken over by Rick Blair and Werner Randelshofer

- Pure-Java implementation of ZeroConf

# JmDNS (cont)

- Progress has slowed but it is relatively stable and useful
- Passes Apple’s Rendezvous (Bonjour) Conformance tests
- Supports service registration and discovery

# JmDNS Class

- Main entry point to the JmDNS subsystem

```
import javax.jmdns.JmDNS;
.
.
.
JmDNS jmdns = new JmDNS();
System.out.println(”Host: “ + jmdns.getHostName() );
System.out.println(”Interface: “ + jmdns.getInterface() );

ServiceInfo si[] = jmdns.list(”_http._tcp.local.”);

jmdns.addServiceTypeListener( new MyServiceTypeListener() );
```

# ServiceInfo Class

- Encapsulates info about a JmDNS Service

```
import javax.jmdns.ServiceInfo;
.
.
.
ServiceInfo
System.out.println(”Host: “ + jmdns.getHostName() );
System.out.println(”Interface: “ + jmdns.getInterface() );

ServiceInfo si[] = jmdns.list(”_http._tcp.local.”);

System.out.println(”Service 0 : “ + si[ 0 ].getServer() + “--”
    + si[ 0 ].getPort() + “--” + si[ 0 ].getNiceTextString() );
```

# Listener Interfaces

- `ServiceListener`
  - Additions, Removals
- `ServiceTypeListener`
  - New service type discovery
- Both listen for `ServiceEvent`s

# Basic JmDNS Examples

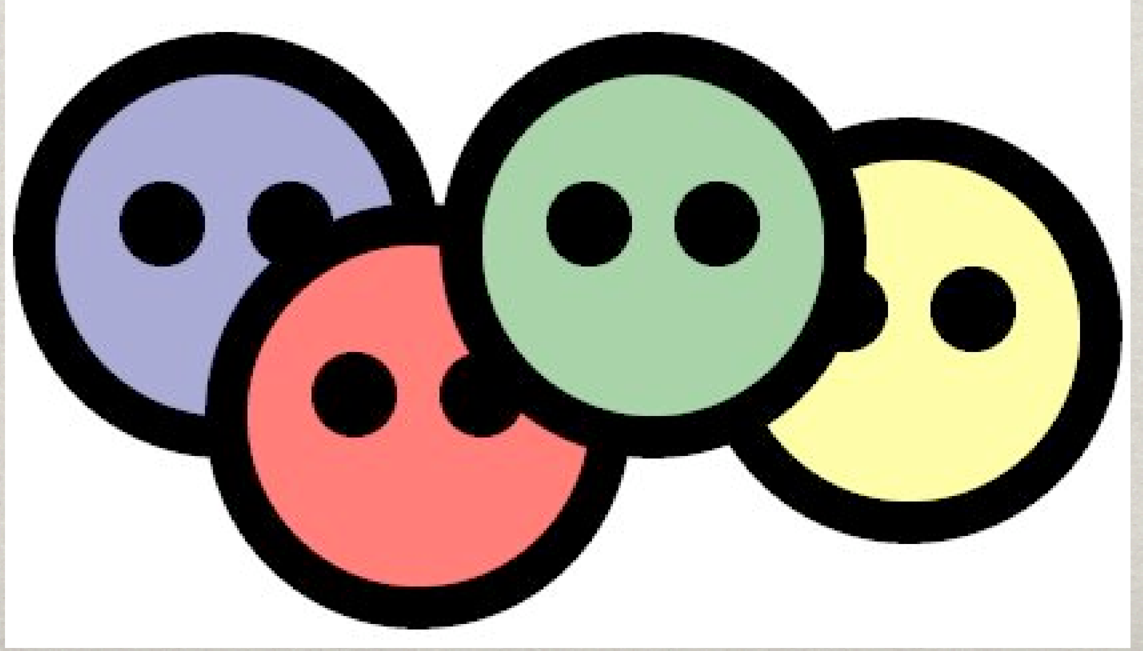
# Using a Service w/ JmDNS Example

# Registering a Service w/ JmDNS Example

# FOAFfinger Example

# What's a FOAF?

- "The Friend of a Friend (FOAF) project is about creating a Web of machine-readable homepages describing people, the links between them and the things they create and do."



# FOAF

- Based on RDF and is used to express things like:
  - “My name is...”
  - “I work for...”
  - “I am interested in...”
  - “Here’s my goofy picture...”

# FOAF and WebPages

- FOAF can help capture relationships, links, etc. for finding resources of interest, like-minded individuals, etc.
- Think Orkut + Craig's List

# FOAFFinger

- Damian Steer put together a JmDNS-based app to find people on local links
- Uses a custom application protocol: `_foafcon._tcp.local.`
- Reuses HTTP for transport -- good idea!

# Brainstorming

# References

- Cheshire, Steinberg, “Zero Configuration Networking: The Definitive Guide”, O’Reilly and Associates, 2005.
- http://www.zeroconf.org
- http://www.multicastdns.org
- http://www.dns-sd.org
- http://jmdns.sourceforge.net
- http://developer.apple.com/networking/bonjour
- http://www.foaf-project.org/
- http://rdfweb.org/people/damian/foaffinger
- http://tivohme.sourceforge.net/
- http://avahi.org

# Examples

- Examples:
  - http://www.bosatsu.net/talks/JmDNS-Examples.zip
- Questions/Feedback:
  - brian@bosatsu.net

# Please write your reviews

Feedback/Questions:
brian@bosatsu.net