Single Packet Authorization

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Agenda

- Single Packet Authorization
  - The basics
  - Community status
- Introducing the SPA C implementation
  - fwknop-c client, upcoming fwknop-c server, and the libfko library
  - Development strategy
  - Supported operating systems
- Advanced topics
  - SPA through HTTP proxies
  - Port randomization for both the SPA packet and NAT'd services
  - Creating “ghost” services with SPA
- Live demo

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The Basics...

- Service protection behind a default-drop packet filter. Anyone scanning for such a service cannot even see that it is listening – let alone exploit a vulnerability or brute-force a password in the protected service.*
- Access granted only after passively collected information is verified.
- SPA is next-generation port knocking, with strong encryption and non-replayability.

* This is not to say that the firewall itself or the packet collection mechanism has no vulnerabilities.

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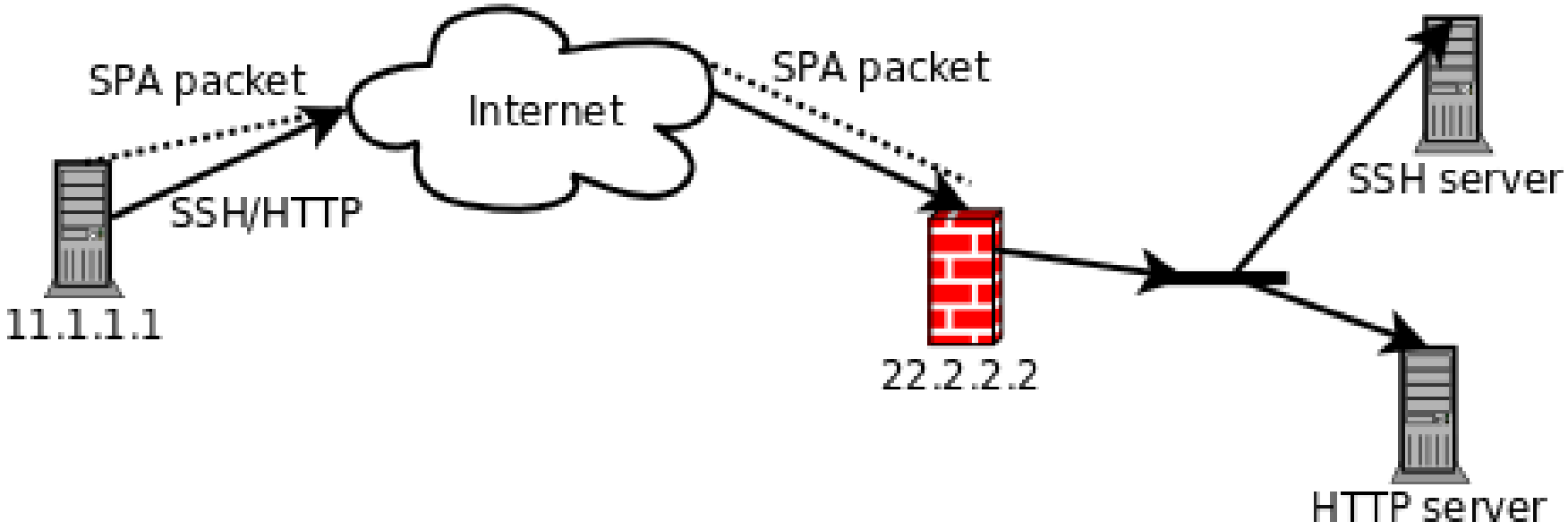
SPA Network Architecture



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Why Not Just Look for Brute Force Password Guessing Attempts?

- DenyHosts, fail2ban, custom log parsers, etc...
- “Relay Server Tactic Dupes Auto-Reporting”
  - http://www.theregister.co.uk/2008/07/14/brute_force_ssh_attack/
- Exploits commonly have nothing to do with guessing a weak password (Debian OpenSSL vuln, overflow vulnerabilities from time to time)... *and this is only SSH*.

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From PK to SPA

- Gain access to sshd after:
  - Single packet to port 12345 (nmap or a web browser can function as a PK client).
  - Or... multiple packets to a sequence of pre-defined ports (generally need a custom client unless the sequence is < 3 ports long).
  - Or... multiple packets form an encrypted sequence with a shared key (really need a custom client).
  - Or... a single packet with appropriately built application layer data (this is SPA).

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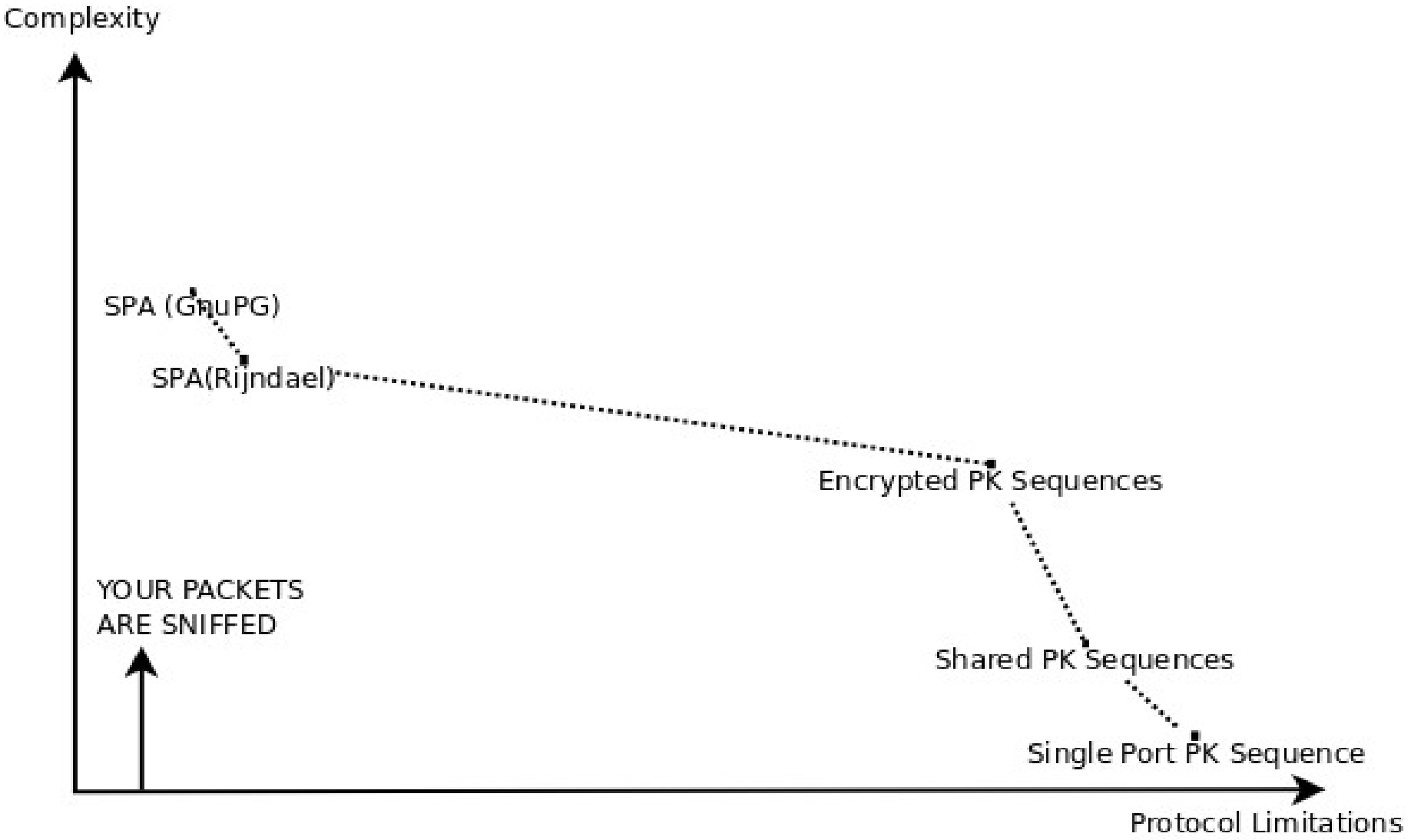
PK vs. SPA – Complexity vs. Protocol Limitations



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SPA and the Security Community

- fwknop downloads (all versions):
  - 2006: 2,768
  - 2007: 6,976
  - 2008: 18,292 (9 software releases)
  - 2009: 10,503 (so far this year with 3 software releases – significant development time devoted to libfko)

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User Contributions

- The big one: libfko + C client/server + FKO perl bindings (Damien Stuart)
- morpheus-fwknop UI (Daniel Lopez)
- HTTP proxy support (Jonathan Bennett)
- ipfw 'sets' support (Julien Picalaus)
- iptables cross-connection persistence (Martin Tan)
- ssh-fwknop (Richard Lundeen – Google Code project)

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The fwknop-1.9.12 release

- Uses the FKO perl module by default.
- Has the ability to recover from interface outage and admin down/up cycles – useful when fwknopd is deployed in conjunction with DHCP or ppp end points.
- HTTP proxy support.
- Can acquire SPA packets via UDP or TCP sockets directly – no libpcap required in either of these modes.

http://www.cipherdyne.org/fwknop/

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Competing Implementations

- Over 30 total port knocking and/or SPA implementations (http://www.portknocking.org/).
- Each with a slight variation on PK or SPA, though few are regularly updated except for fwknop (which has 36 releases since 2004).
- The most interesting competing implementation is *knockknock* by Moxie Marlinspike.

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Trends?

- SPA usage is up, but widespread deployment has a long way to go.
- A modifier will be efforts to package SPA software for various platforms, and efforts to support different firewalls and/or router ACL's.
- People still concentrate on *detection* of SPA vs. *exploitation* of SPA.
- *Open question*: To what extent are PK/SPA techniques used by the blackhat community or in botnets? *...This would make a great topic for a research paper*.

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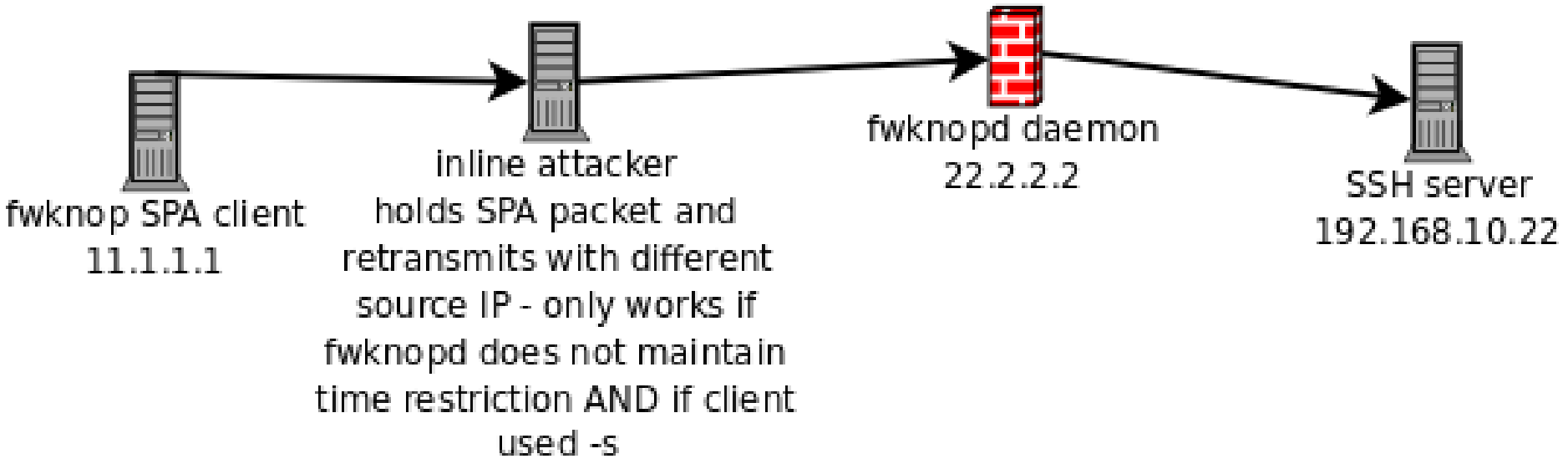
Old SPA Man-In-The-Middle Attack

- Given that people concentrate on detection, it's only fair to present an attack as well.
- fwknop has ***not*** been vulnerable since 2006.
- It would be interesting to determine which other SPA implementations are also vulnerable to this.



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fwknop-c + libfko

- libfko is a C library that third party applications can link against in order to implement the SPA protocol.
- Simplifies the implementation of both SPA client and server applications.
- Small footprint brings SPA to embedded systems that have limited resources (e.g. OpenWRT on a small router), and to systems where there is no perl interpreter and no compiler installed.
- FKO perl bindings already exist, with other language support planned.

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libfko

- Supports Linux, FreeBSD, Mac OS X, Solaris, and Windows.
- The SPA packet format is built by libfko functions via an SPA-context data structure.
- Depends on gpgme for GunPG SPA operations.
- SPA packet format:

  random_data:user:timestamp:version:mode:access_str:internal_digest

  4070524269054661:root:1257137439:1.9.12:1:127.0.0.2,tcp/22:-1:0ey4FayNQlUSnS0qL5q4EMYaOWIXGSVODbtXQ2EQUas

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libfko API

- SPA packet data is built from a series of get_* and set_* functions:

- DLL_API int fko_set_rand_value(fko_ctx_t ctx, const char *val);
- DLL_API int fko_set_username(fko_ctx_t ctx, const char *spoof_user);
- DLL_API int fko_set_timestamp(fko_ctx_t ctx, int offset);
- DLL_API int fko_set_spa_message_type(fko_ctx_t ctx, short msg_type);
- DLL_API int fko_set_spa_message(fko_ctx_t ctx, const char *msg_string);
- DLL_API int fko_set_spa_nat_access(fko_ctx_t ctx, const char *nat_access);

- Once the SPA packet data is built, the client sends it out on the wire based on transmission needs (UDP vs. other socket type, auto-resolution of external NAT address of local network, etc.).

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FKO perl module

```
#!/usr/bin/perl -w


use FKO;
my $fko = FKO->new();
my $err = $fko->spa_message('0.0.0.0,tcp/22');
### error checking...
$err = $fko->spa_data_final();
my $spa_data = $fko->spa_data();


### send over UDP socket...
exit $err;
```

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fwknop-c client/server

- The fwknop-c client is finished, and passes the fwknop test suite.
- The server is currently in development – will depend on libpcap, and the tricky part is handling the underlying firewall interface. The perl version depends on IPTables::Parse and IPTables::ChainMgr.
- Will be highly portable considering where libfko already runs.

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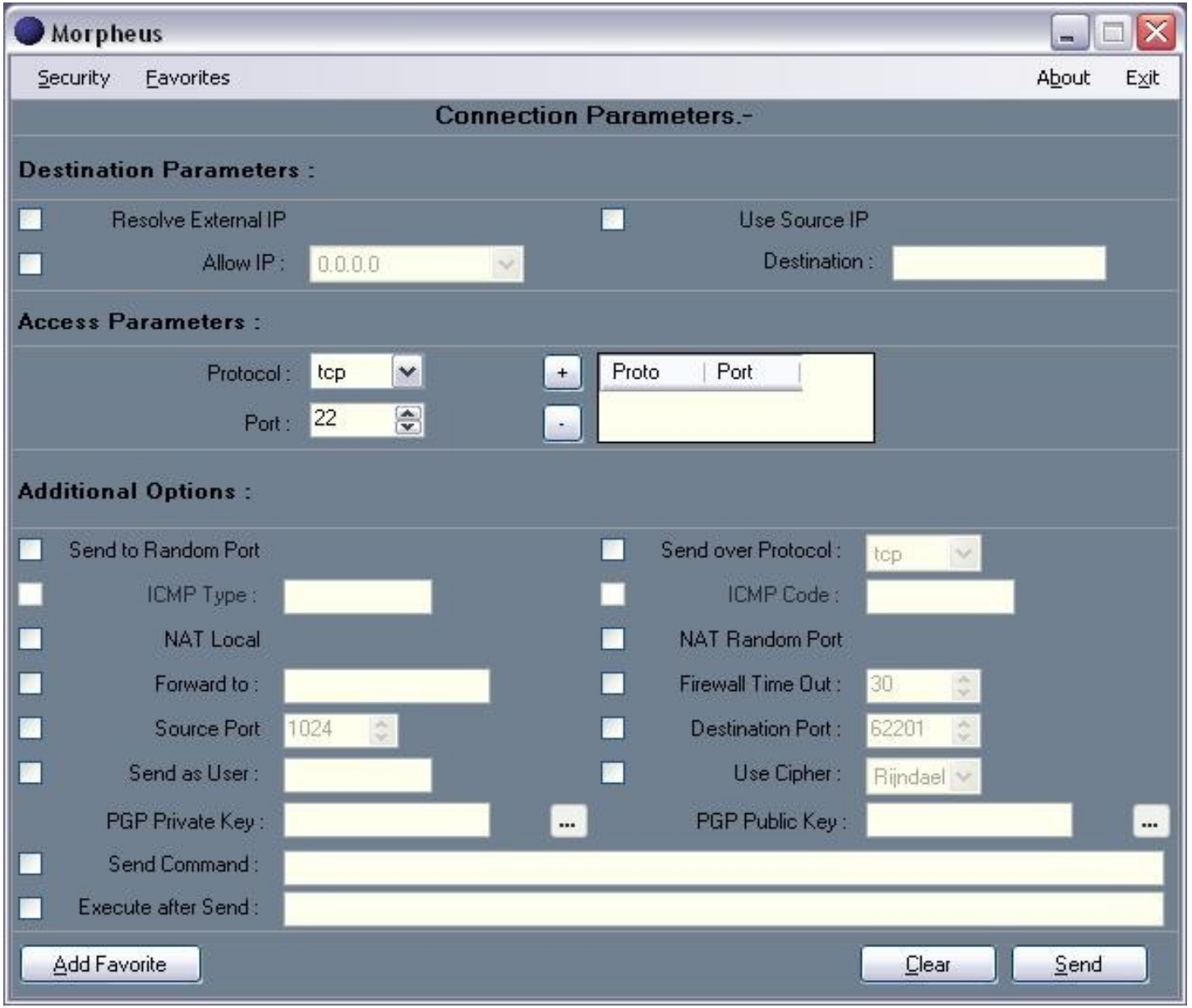
morpheus-fwknop UI



Advanced Topics + Live Demos...

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Example 1: SPA over an HTTP proxy

- Requires a relaxation of the “single” part of SPA.
- Need to be able to set HTTP headers such that a proxy (such as Squid) recognizes where the SPA/HTTP request goes.
- The fwknop client builds an HTTP request with a leading '/', and the remainder is normal base64 encoded SPA data.
- Follow-on connections are made as usual.

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Example 2: Port Randomization

- SPA destination port is randomized AND the service port itself is randomized (with NAT rules building the appropriate access).
- Essentially asking to access a service via a non-standard port.
- To an observer, difficult to identify what is going on without looking at every packet – no correspondence between connections and “expected” port numbers.
- Live demo...

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Example 3: Creating a “Ghost” Service with SPA

- On the server side, and service can be offered over a port which fwknopd co-opts for other access for your source IP.
- Example: the server can be running a webserver on port 80, but NAT'd access to sshd can be requested through port 80 for the SPA client IP. Everyone else always just sees the HTTP server.
- Live demo...

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Conclusions

- The security community is gradually embracing SPA in some cases, but there is a long way to go.
- Full fwknop-c server support is on the way, and client support exists today. OpenWRT server support will not be far behind.
- Effective NAT integration implies advantages in the face of attackers armed with packet sniffers.

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Questions?

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