Solaris 10 Security

Deep Dive

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Agenda

- Overview of Solaris 9 Security
- Key Solaris 10 Security Enhancements
- Additional Security Features

Solaris 9 Security Overview

- Access Control Lists
- Role-based Access Control
- IPsec / IKE
- Solaris Auditing
- TCP Wrappers (inetd)
- Flexible Crypt
- Signed Patches
- Granular Packaging
- SSL-enabled LDAP
- WAN Boot
- IKE Hardware Accel.
- Solaris Fingerprint DB
- Solaris Secure Shell
- Kerberos
- /dev/[u]random
- Enhanced PAM Framework
- Smartcard Framework
- Java 1.4 Security
- SunScreen 3.2
- Solaris Security Toolkit
- sadmind DES Auth
- LDAP Password Management

Security Goals - Defensive

- Provide strong assurance of system integrity
  - Simplify building and deploying of secure solutions
  - Monitor system state for unexpected change
  - Audit security relevant changes
- Defend system from unauthorized access
  - Contain damage caused by unauthorized access
  - Minimize privileges given to people and processes
  - Filter inbound communications into the system

Security Goals—Enabling

- Secure authentication of all active subjects
  - > Use strong user and host level authentication
  - > Integrate authentication mechanisms
  - > Leverage a unified authentication infrastructure
- Protect communications between endpoints
  - > Provide private data transmissions
  - > Verify integrity of received data
  - > Securely establish and protect keys

Security Goals—Deployable

- Emphasize integratable stack architecture
  - Enable pluggable use of 3rd party security providers
  - Provide abstracted APIs for customers
  - Offer robust security platform for Sun's products
- Interoperable with other security architectures
- Ease management and use of security features
  - Transparently maintain security infrastructure
  - Simplify and centralize security policy definition
  - Minimize visibility of secure features to end users
- Receive independent assessment of security

Stronger “Out of the Box” Posture

- New Minimal Meta-Cluster (SUNWCrnet)
  - Solid foundation for minimizing systems.
- New Hardened Service Profile
  - generic_limited_net
- More Conservative, Post-Install Posture
  - More services are “off” by default.
  - Stronger default security settings.
- Fortified Code Base
  - Cryptographically signed ELF objects.
  - Ongoing, continuous software security reviews.
  - Security flaw impact containment.

Solaris 10 Minimization Example

Meta Cluster	Size (MB)	# Pkgs	# Set-UID	# Set-GID
Reduced Networking	191	92	28	11
Core	219	139	34	13
End User	2100	604	57	21
Developer	2900	844	59	21
Entire	3000	908	72	22
Entire + OEM	3000	988	80	22

Information was collected from Solaris 10 07/2005 (Update 1, Build 05)

Signed Executables Example

```
# file /usr/lib/ssh/sshd
/usr/lib/ssh/sshd:      ELF 32-bit MSB executable SPARC Version 1, dynamically
linked, stripped

# elfsign verify -e /usr/lib/ssh/sshd
elfsign: verification of /usr/lib/ssh/sshd passed.

# digest -v -a md5 /usr/lib/ssh/sshd
md5 (/usr/lib/ssh/sshd) = b94b091a2d33dd4d6481dffa784ba632

[... process MD5 fingerprint using the Solaris Fingerprint Database...]

 b94b091a2d33dd4d6481dffa784ba632 - (/usr/lib/ssh/sshd) - 1 match(es)
     * canonical-path: /usr/lib/ssh/sshd
     * package: SUNWsshdu
     * version: 11.10.0,REV=2005.01.21.15.53
     * architecture: sparc
     * source: Solaris 10/SPARC
```

Service Management Facility

- New model for service management.
- SMF benefits include:
  - Consistent service representation
  - Common set of management interfaces
  - Parallelized startup of services
  - Automatic dependency resolution
  - Delegated service restarts
- Simplifies disabling unused services.
  - Solaris Security Toolkit uses SMF in Solaris 10.
- Integrated with RBAC and Privileges

SMF Example #1

```
# svcs network/inetd
STATE          STIME    FMRI
online         1:28:15 svc:/network/inetd:default

# svcadm disable network/inetd
# svcs network/inetd
STATE          STIME    FMRI
disabled       1:46:31 svc:/network/inetd:default

# svcs -x -v network/inetd
svc:/network/inetd:default (inetd)
 State: disabled since Wed Dec 01 01:46:31 2004
Reason: Disabled by an administrator.
   See: http://sun.com/msg/SMF-8000-05
   See: man -M /usr/share/man -s 1M inetd
Impact: 18 services are not running:
        svc:/network/rpc-100068_2-5/rpc_udp:default
        svc:/network/rpc/gss:ticotsord
        [...]
```

SMF Example #2

```
# svcprop -v -p defaults network/inetd
defaults/bind_addr astring ""
defaults/bind_fail_interval integer -1
defaults/bind_fail_max integer -1
defaults/con_rate_offline integer -1
[...]
defaults/stability astring Evolving
defaults/tcp_trace boolean false
defaults/tcp_wrappers boolean false

# svcs -x network/smtp
svc:/network/smtp:sendmail (sendmail SMTP mail transfer agent)
 State: maintenance since Wed Dec 01 01:31:35 2004
Reason: Start method failed repeatedly, last exited with status 208.
   See: http://sun.com/msg/SMF-8000-KS
   See: sendmail(1M)
Impact: 0 services are not running.
```

SMF Example #3

```
# svcprop -v -p start apache2
start/exec astring /lib/svc/method/http-apache2\ start
start/timeout_seconds count 60
start/type astring method
start/user astring webservd
start/group astring webservd
start/privileges astring basic,!proc_session,!proc_info,!file_link_any,net_privaddr
start/limit_privileges astring :default
start/use_profile boolean false
start/supp_groups astring :default
start/working_directory astring :default
start/project astring :default
start/resource_pool astring :default
```

SMF Example #4

```
# svcprop -p httpd -p general apache2
general/enabled boolean false
general/action_authorization astring sunw.apache.oper
general/entity_stability astring Evolving
httpd/ssl boolean false
httpd/stability astring Evolving
httpd/value_authorization astring sunw.apache.admin
```

User/Password Management

- Local Password Complexity Checks
  - Login Name, White Space
  - Mininum Alpha, Non-Alpha, Upper, Lower, (Consequtive) Repeats, Special, Digits, etc.
- Local Password History
  - 0 to 26 Passwords Deep.
- Local Banned Password List (Dictionary)
- Local Account Lockout (3 Strikes)
- New Password Command Options:
  - Non-Login, Locked and Unlocked

Secure Remote Access - Kerberos

Kerberos Enhancements

- MIT Kerberos 1.3.2 Refresh
- KDC Incremental Propagation
- kclient Auto-configuration Tool
- pam_krb5_migrate KDC Auto-population Tool
- TCP and IPv6 Support
- AES-128, AES-256, 3DES, RC4-HMAC Support
- SPNego – GSS-API Dynamic Security Negotiation
- Bundled Remote Applications (Clients & Servers)
  - telnet, ftp, rlogin, rsh, rcp, rdist, Secure Shell, Mozilla and Apache
- Interoperability Fixes

Secure Remote Access - SSH

Secure Shell Enhancements

- OpenSSH 3.6p2++ Refresh
- GSS-API Support
- Enhanced Password Aging Support
- Keyboard “Break” Sequence Support
- X11 Forwarding “on” by default
- RC4, AES CTR mode Encryption Support
- /etc/default/login Synchronization
- SSH2 Rekeying
- Server Side Keepalives

Process Privileges

- Execute with only those privileges that are actually needed.
  - Delegation of “root” authority.
  - Completely backward compatible.
  - Allows fine-grained control of privilege (50 and counting)
  - Privileges are inheritable, relinquishable, etc.
- Check for privileges and not just UID == 0!
- Mitigate effects of future flaws.
  - Drop any privileges you do not need (or others once you are done with them).

Process Privileges Listing

contract_event	contract_observer	cpc_cpu	dtrace_kernel
dtrace_proc	dtrace_user	file_chown	file_chown_self
file_dac_execute	file_dac_read	file_dac_search	file_dac_write
file_link_any	file_owner	file_setid	ipc_dac_read
ipc_dac_write	ipc_owner	net_icmpaccess	net_privaddr
net_rawaccess	proc_audit	proc_chroot	proc_clock_highres
proc_exec	proc_fork	proc_info	proc_lock_memory
proc_owner	proc_priocntl	proc_session	proc_setid
proc_taskid	proc_zone	sys_acct	sys_admin
sys_audit	sys_config	sys_devices	sys_ipc_config
sys_linkdir	sys_mount	sys_net_config	sys_nfs
sys_res_config	sys_resource	sys_suser_compat	sys_time
gart_access	gart_map		

Process Privilege Sets

- Effective Set
  - Privileges currently in effect
  - Privileges can be added or dropped
- Permitted Set
  - Upper bound on Effective Set for this process
  - Privileges can be dropped (changes Effective)
- Inheritable Set
  - Default privileges given to child processes
  - Becomes child's Permitted and Effective Set
- Limit Set
  - Upper bound for Inheritable Set
  - Typically contains all privileges

Process Privilege Inheritance

- Limit (L) is unchanged
- L is used to bound privs in Inheritable (I)
  - I' = I ∩ L
- Child's Permitted (P') & Effective (E') are:
  - P' = E' = I'
- Typical process
  - P = E = I = {basic}
  - L = {all privileges}
  - Since P = E = I, children run with same privileges

Root Account Still Special

- root owns all configuration/system files
  - uid 0 is therefore still very powerful
- Privilege escalation prevention
  - Require ALL privileges to modify objects owned by root when euid ≠ 0
  - Fine tuning in certain policy routines
    - Not all privileges, only nosuid mounts
- Prefer services be non-0 uid + privileges
  - Additive approach is safer than uid 0 – privileges

Using Process Privileges

Four Primary Methods

- ppriv(1)

```
# ppriv -e -D -s -proc_fork,-proc_exec /bin/sh -c finger
sh[387]: missing privilege "proc_fork" (euid = 0, syscall = 143) needed at cfork+0x18
/bin/sh: permission denied
```

- User Rights Management (RBAC)

```
# grep "Network Management" /etc/security/exec_attr
Network Management:solaris:cmd:::/sbin/ifconfig:privs=sys_net_config
Network Management:solaris:cmd:::/sbin/route:privs=sys_net_config
```

- Service Management Framework (SMF)

```
# svcprop -p start system/cron | grep privileges
start/privileges astring :default
start/limit_privileges astring :default
```

- Privilege Aware Applications

  Drop unneeded privileges, bracket privileged code, etc.

Process Privileges Example #1

```
# ppriv -S `pgrep rpcbind`
933:    /usr/sbin/rpcbind
flags = PRIV_AWARE
        E: net_privaddr,proc_fork,sys_nfs
        I: none
        P: net_privaddr,proc_fork,sys_nfs
        L: none

# ppriv -S `pgrep statd`
5139:   /usr/lib/nfs/statd
flags = PRIV_AWARE
        E: proc_fork
        I: none
        P: proc_fork
        L: none
```

Process Privileges Example #2

```
# ppriv -e -D -s -proc_fork,proc_exec /bin/sh -c finger
sh[387]: missing privilege "proc_fork" (euid = 0, syscall = 143) needed at cfork+0x18
/bin/sh: permission denied


# touch /foo
# chown bin /foo
# chmod 600 /foo
# cat /foo
# ppriv -e -D -s -file_dac_read cat /foo
cat[393]: missing privilege "file_dac_read" (euid = 0, syscall = 225) needed at
ufs_access+0x3c
cat: cannot open /foo


# ppriv -e -s -file_dac_read /bin/sh
# truss -f -vall -wall -tall cat /foo
[...]
397:    open64("/foo", O_RDONLY)                Err#13 EACCES [file_dac_read]
[...]
```

Process Privileges Example #3

Solaris 9 Network Management Rights Profile

```
# grep "Network Management" /etc/security/exec_attr
Network Management:suser:cmd:::/usr/sbin/ifconfig:uid=0
Network Management:suser:cmd:::/usr/sbin/route:uid=0
[...]
```

Solaris 10 Network Management Rights Profile

```
# grep “Network Management” /etc/security/exec_attr
Network Management:solaris:cmd:::/sbin/ifconfig:privs=sys_net_config
Network Management:solaris:cmd:::/sbin/route:privs=sys_net_config
[...]
```

Solaris 10 Custom (BART) Rights Profile

```
# grep "^File Integrity:" /etc/security/exec_attr
File Integrity:solaris:cmd:::/usr/bin/bart:privs=file_dac_read,file_dac_search
```

Process Privilege Debugging

web_svc zone: # svcadm disable apache2

global zone: # privdebug -v -f -n httpd

web_svc zone: # svcadm enable apache2

global zone: [output of privdebug command]

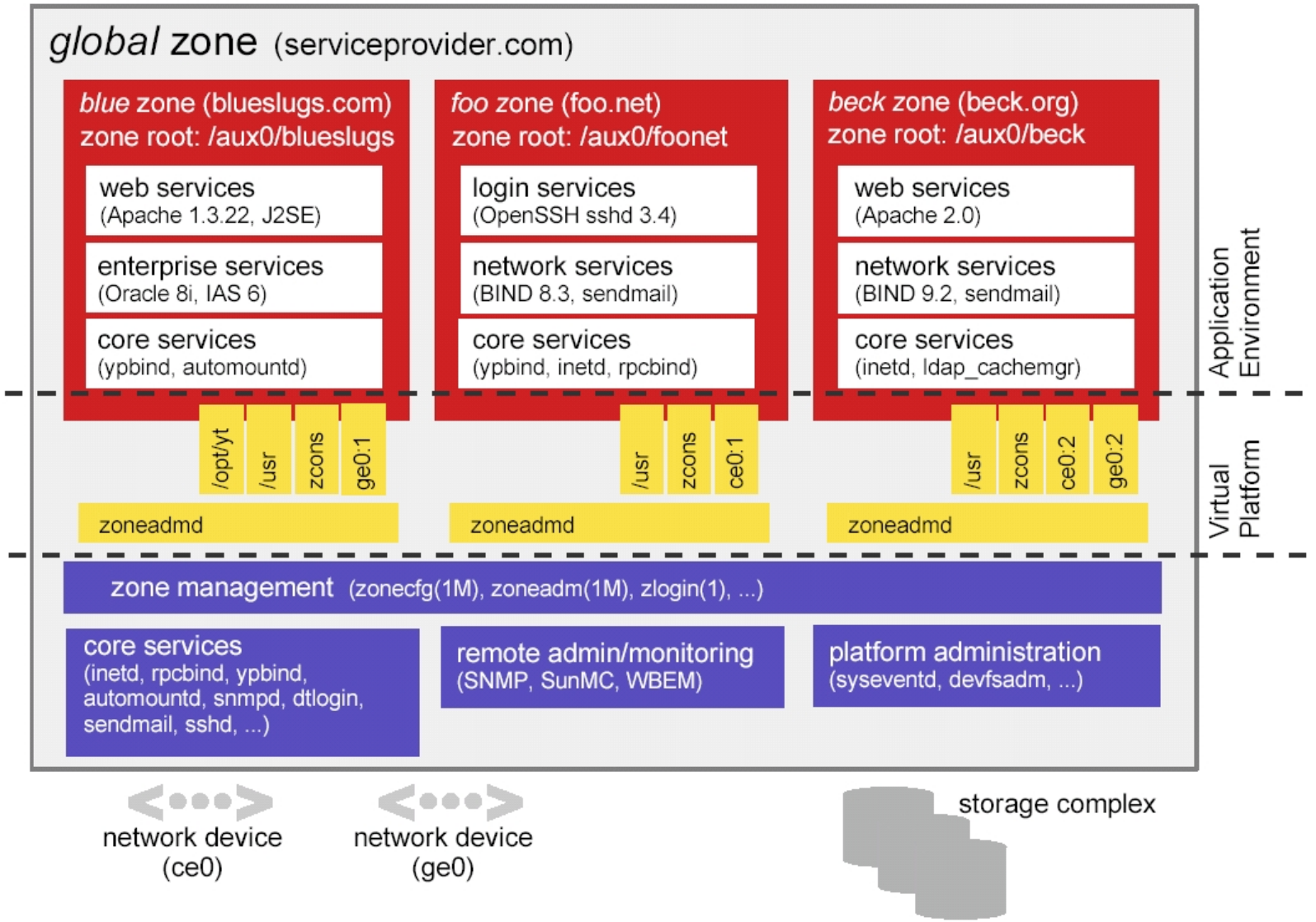
STAT	TIMESTAMP	PPID	PID	PRIV	CMD
USED	2734148820138 90	4642	4647	net_privaddr	httpd
USED	2734157261828 12	4642	4647	proc_fork	httpd
USED	2734166836696 22	1	4648	proc_fork	httpd
USED	2734166892058 82	1	4648	proc_fork	httpd
USED	2734166940022 23	1	4648	proc_fork	httpd
USED	2734166988147 88	1	4648	proc_fork	httpd
USED	2734167033772 26	1	4648	proc_fork	httpd

privdebug is available from the OpenSolaris Security Community:
http://www.opensolaris.org/os/community/security/

Containers and Zones

- Containers Overview
  - Containers are virtualized application environments.
  - Thousands of containers can be installed on a system.
  - Each acts like a separate operating system.
  - Each is in fact running on the same kernel.
- Containers Security Overview
  - Containers have security boundaries around them.
  - Containers operate with fewer privileges.
  - Important name spaces are isolated.
  - Processes running in a zone cannot affect other zones.
  - Cross-zone communication via network only (default).
  - Resources within a zone are strictly controlled.

Container Example



Container Security

- By default, global zone “root” can see and do everything.
- Local zones are restricted in order to protect the security of the system:
  - System Calls
  - Device Manipulation
  - Privileges
  - Resources

Container Security – System Calls

- Permitted System Calls:
  - chmod(2), chroot(2), chown(2), and setuid(2)
- Prohibited System Calls:
  - memcntl(2), mknod(2), stime(2), and pset_create(2)
- Limited System Calls:
  - kill(2)

Container Security – Devices

- /dev Permitted System Calls:
  - chmod(2), chown(2), and chgrp(1)
- /dev Prohibited System Calls:
  - rename(2), unlink(2), symlink(2), link(2), creat(2), and mknod(2)
- Forced nodevices mount option
  - Prevents import of malicious device files from NFS and other foreign sources.
- Security audit performed on all drivers included in default zone configuration.

Container Security – Privileges

contract_event	contract_observer	cpc_cpu	dtrace_kernel
dtrace_proc	dtrace_user	file_chown	file_chown_self
file_dac_execute	file_dac_read	file_dac_search	file_dac_write
file_link_any	file_owner	file_setid	ipc_dac_read
ipc_dac_write	ipc_owner	net_icmpaccess	net_privaddr
net_rawaccess	proc_audit	proc_chroot	proc_clock_highres
proc_exec	proc_fork	proc_info	proc_lock_memory
proc_owner	proc_priocntl	proc_session	proc_setid
proc_taskid	proc_zone	sys_acct	sys_admin
sys_audit	sys_config	sys_devices	sys_ipc_config
sys_linkdir	sys_mount	sys_net_config	sys_nfs
sys_res_config	sys_resource	sys_suser_compat	sys_time

Container Example

```
# ppriv -S $$
4610:   -sh
flags = <none>
        E: zone
        I: basic
        P: zone
        L: zone

# dtrace -l
dtrace: failed to initialize dtrace: DTrace device not available in local zone

# prtdiag
prtdiag can only be run in the global zone

# ppriv -D -e route add net default 10.1.2.3
route[4676]: missing privilege "sys_net_config" (euid = 0, syscall = 4) needed at ip_rts_request+0x138
add net default: gateway 10.1.2.3: insufficient privileges

# modunload -i 101
Insufficient privileges to unload a module

# mv /usr/bin/login /usr/bin/login.foo
mv: cannot rename /usr/bin/login to /usr/bin/login.foo: Read-only file system
```

Why run services in Containers?

- Restricted Operations for Enhanced Security
  - Accessing raw memory, DTrace, promiscuous mode snooping, altering network interface and route information, manipulating kernel modules, altering system time, etc.
- Enforcement with Integrity
  - Sparse Root Zones, IP Filter, Restricted Mount, etc.
- Resource Control and Management
  - CPU, Memory, Disk, Networking, etc.
- Observability with Integrity
  - BART, Solaris Auditing, etc.

Basic Auditing and Reporting Tool

- File-level integrity validation tool.
  - Operates in either “create” or “compare” mode.
  - “rules” files define what should be evaluated and how.
  - “manifest” files contain the results.
- Flexible operational methods.
  - Allows “BART” input and output to be stored locally, piped to another process (transmission, compression, encryption, signing, etc.)
- Very small footprint (1 binary).
- Can evaluate all zones from the global zone.
- Can automate and centralize collection using BART, RBAC, Privileges, and SSH!

BART Examples

- BART rules (bart_rules(4))
  /usr/sbin
  CHECK all
- BART manifest (bart_manifest(4))
  /usr/sbin/acctadm F 28356 100555 user::r-x,group::r-x,mask:r-x,other:r-x 414f3bb4
  0 2 ece9d92d00b0c13ed2d56580e3856df7
- BART Create Operation:
  # bart create -r rules > manifest
  # find /usr/lib/nis | bart create -I > manifest
- BART Compare Operation:
  # bart compare ./manifestA ./manifestB
  /usr/sbin/auditd:
  acl control:user::r-x,group::r-x,mask:r-x,other:r-x test:user::r-x,group::r-x,mask:r-x,other:rwx
  contents control:28dd3a3af2fcc103f422993de5b162f3
  test:28893a3af2fcc103f422993de5b162f3

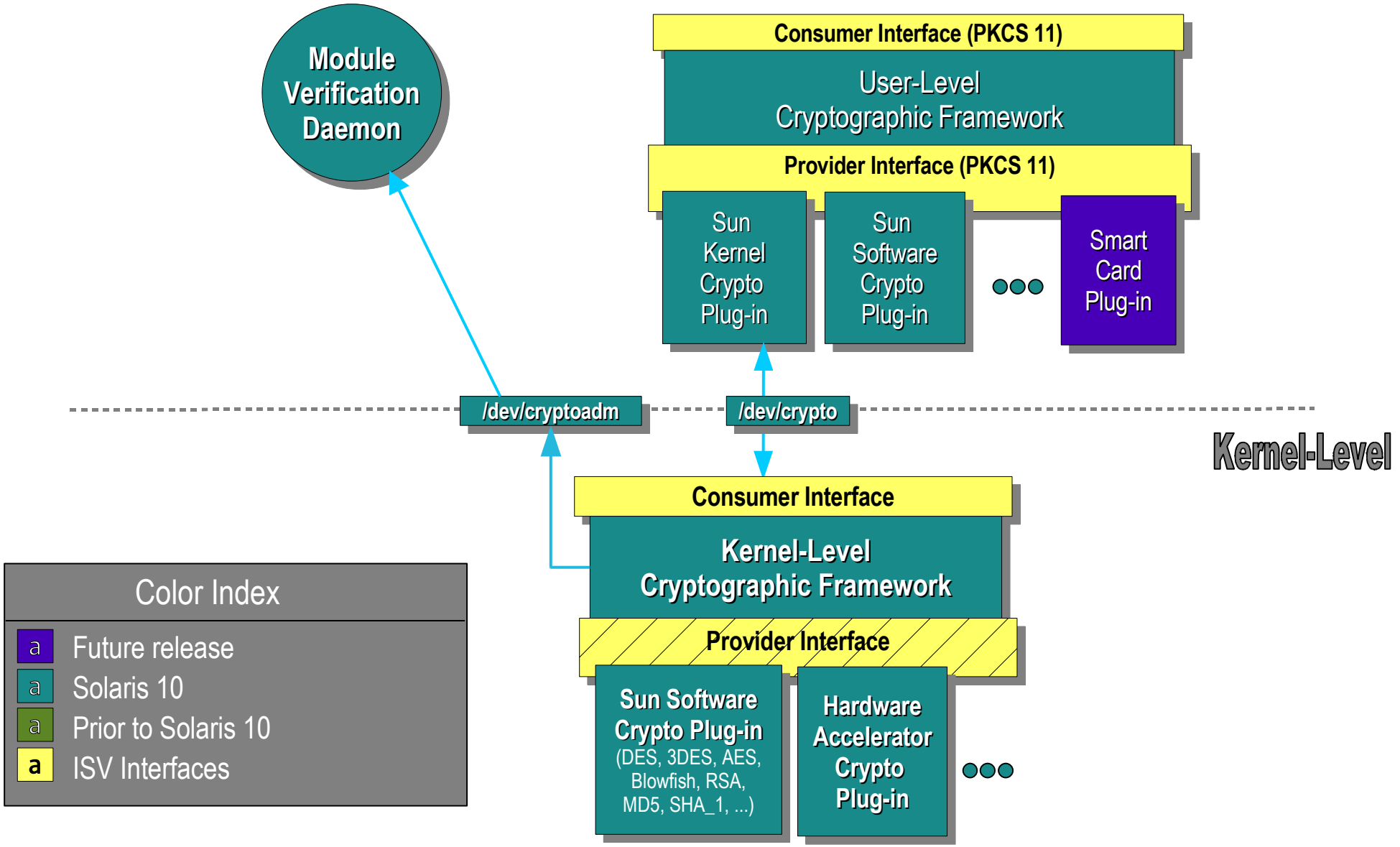
IP Filter

- Stateful and stateless packet inspection.
- Kernel-based packet filtering.
- Protocol proxies (TCP, UDP, FTP, rcmds, etc.)
- Text-based configuration.
- Support for both NAT and PAT.
- SYSLOG Logging.
- Small footprint, high performance.
- Minimal software requirements.

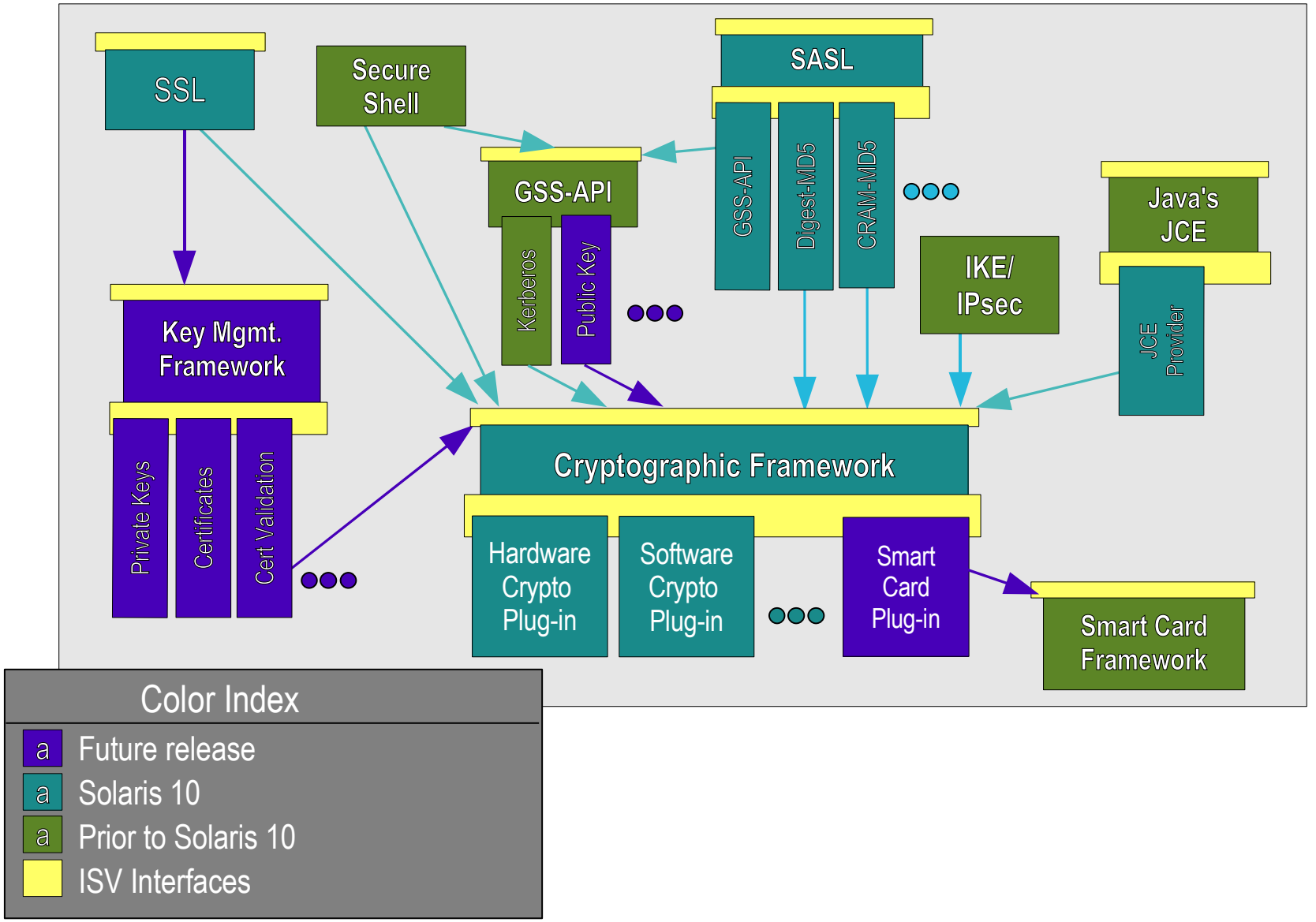
Cryptographic Framework

- Extensible cryptographic interfaces.
  - A common kernel and user-land framework for providing and using cryptographic functionality.
  - A common interface for cryptographic functions whether completed in hardware or software.
  - Extensible framework for vendors to provide custom functionality.
- By default, supports major algorithms.
  - Encryption: AES, RC4, DES, 3DES, RSA
  - Hashing: MD5, SHA-1
  - MAC: DES MAC, MD5 HMAC, SHA-1 HMAC
  - Optimized for both SPARC, Intel and AMD

Crypto Framework Architecture

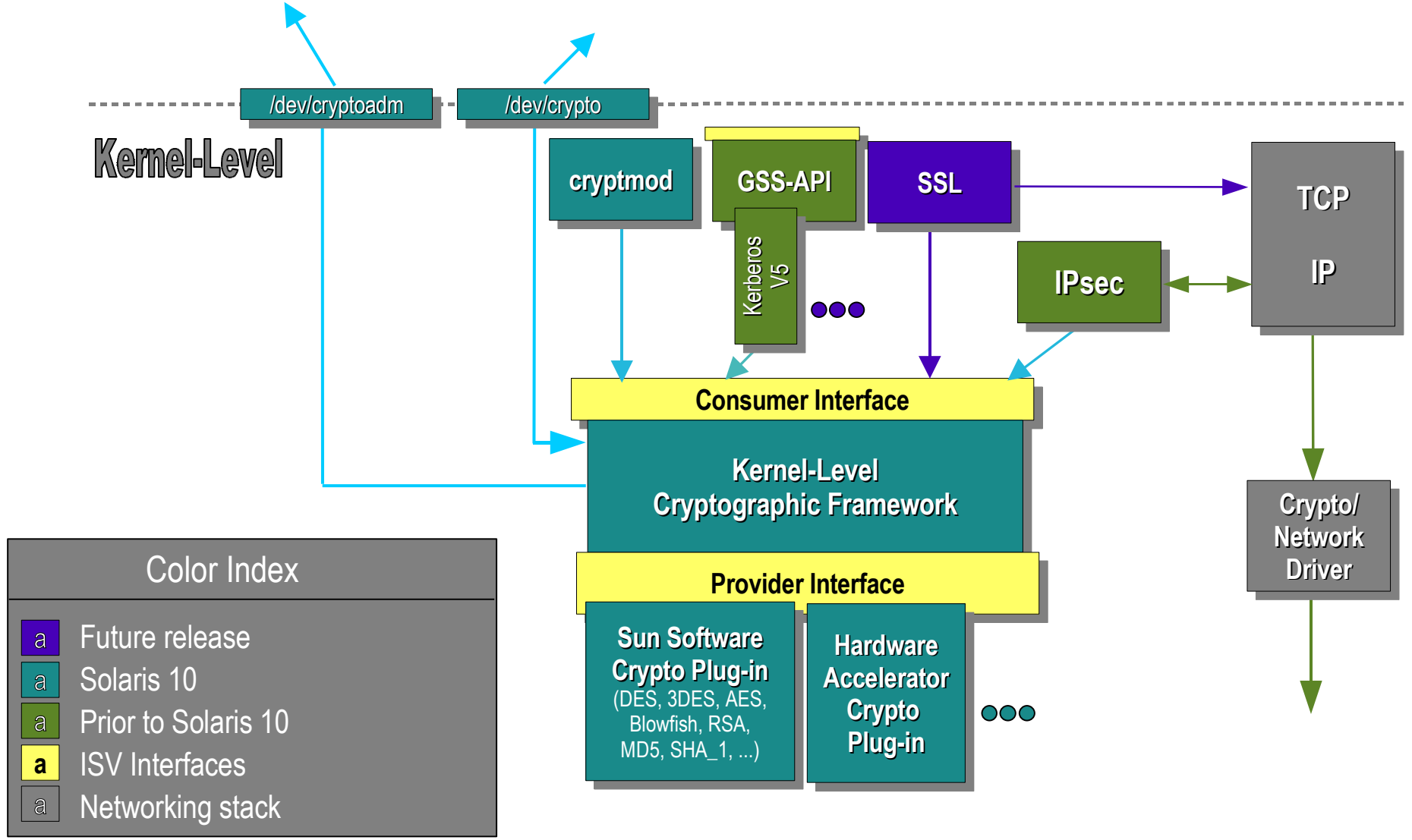


Network Security Architecture



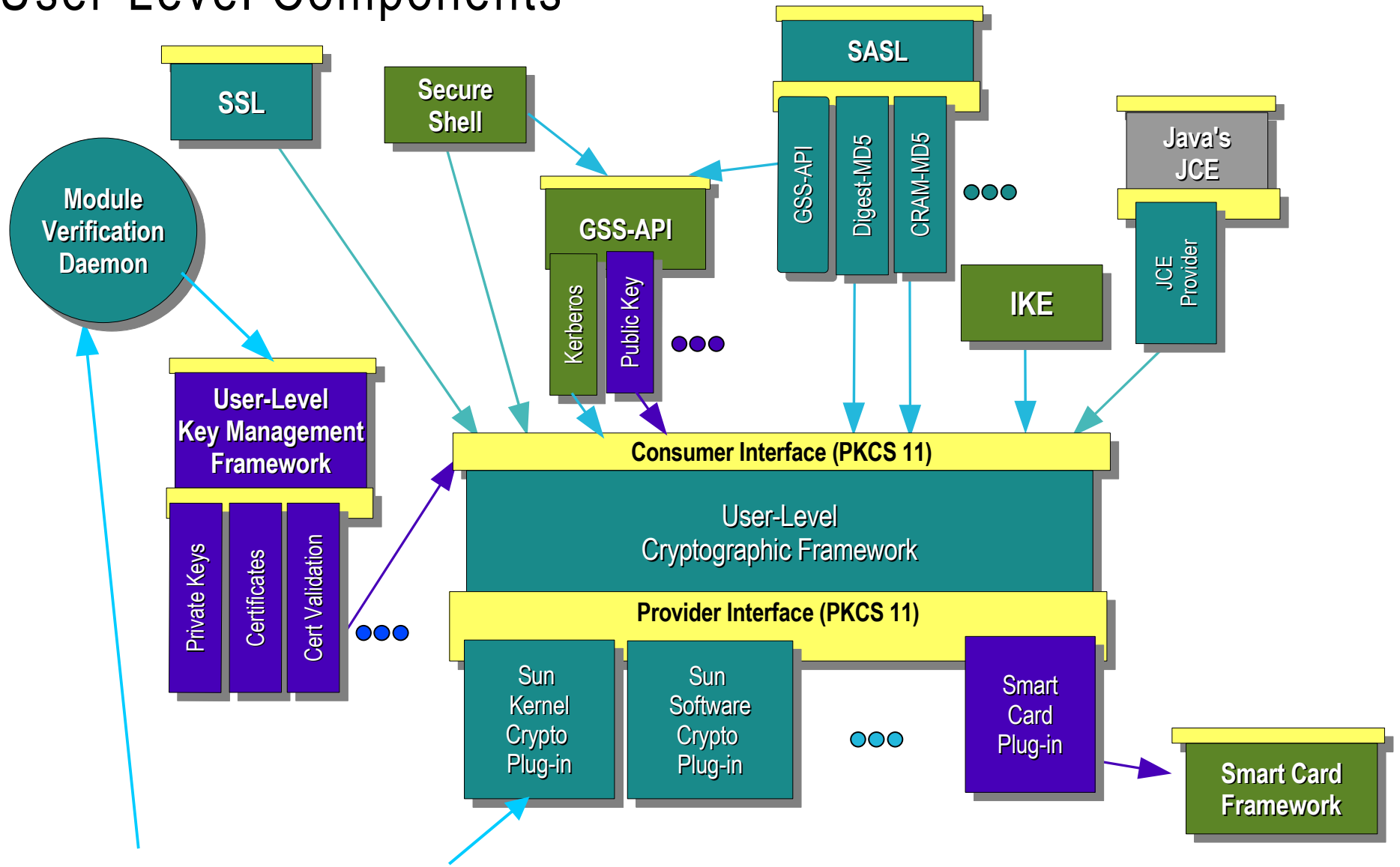
Network Security Architecture

Kernel-level Components

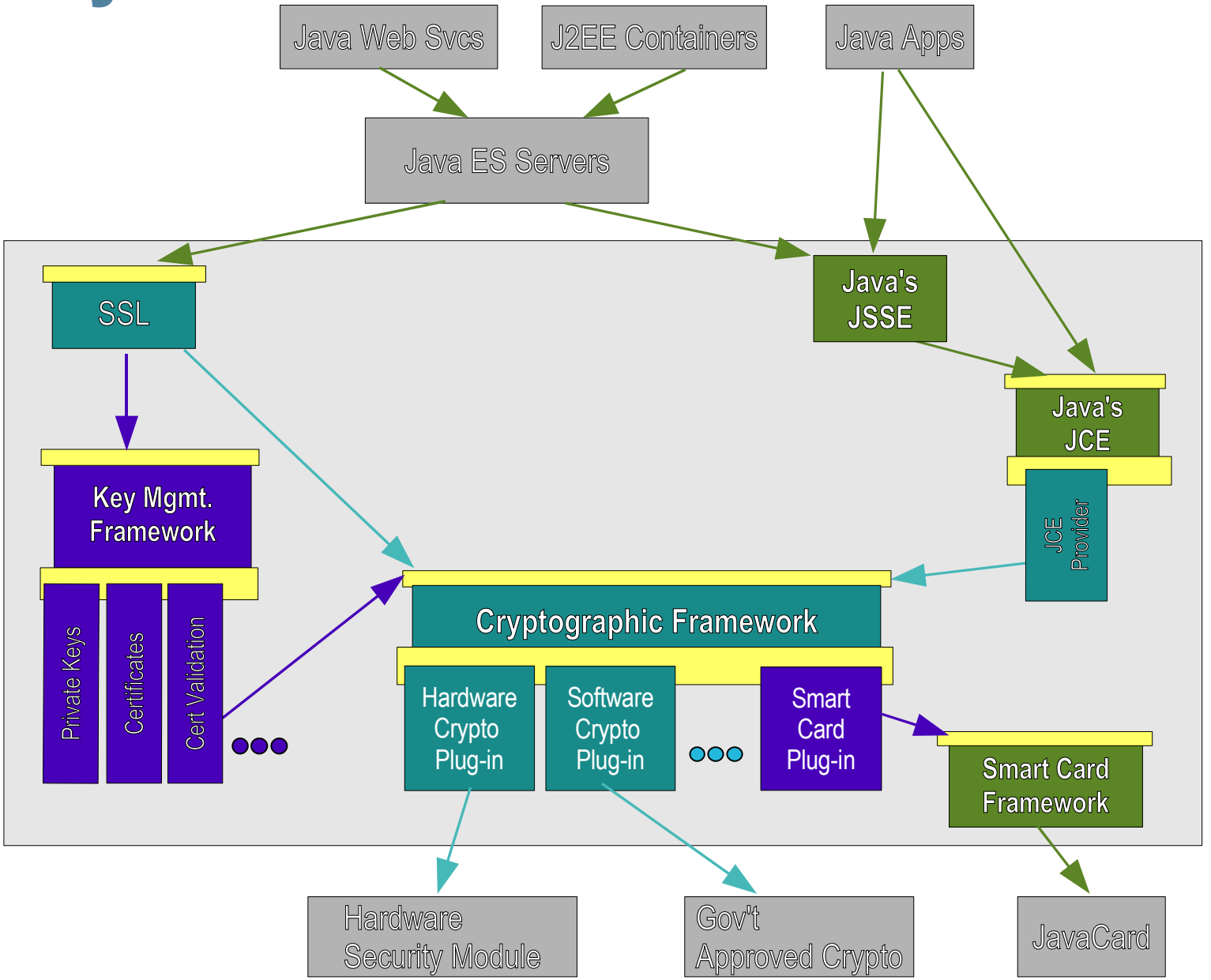


Network Security Architecture

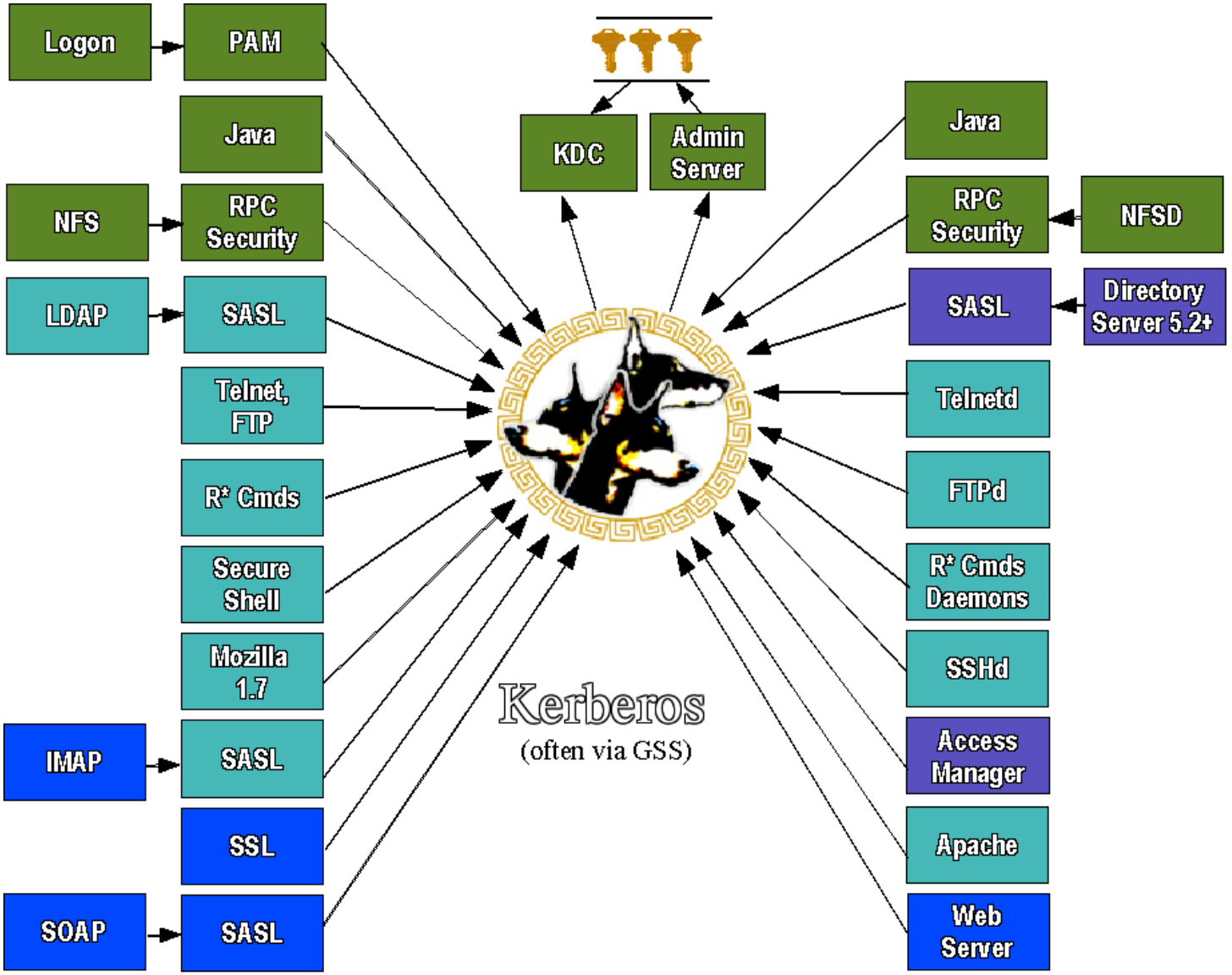
User-Level Components



Security Platform for Web Services



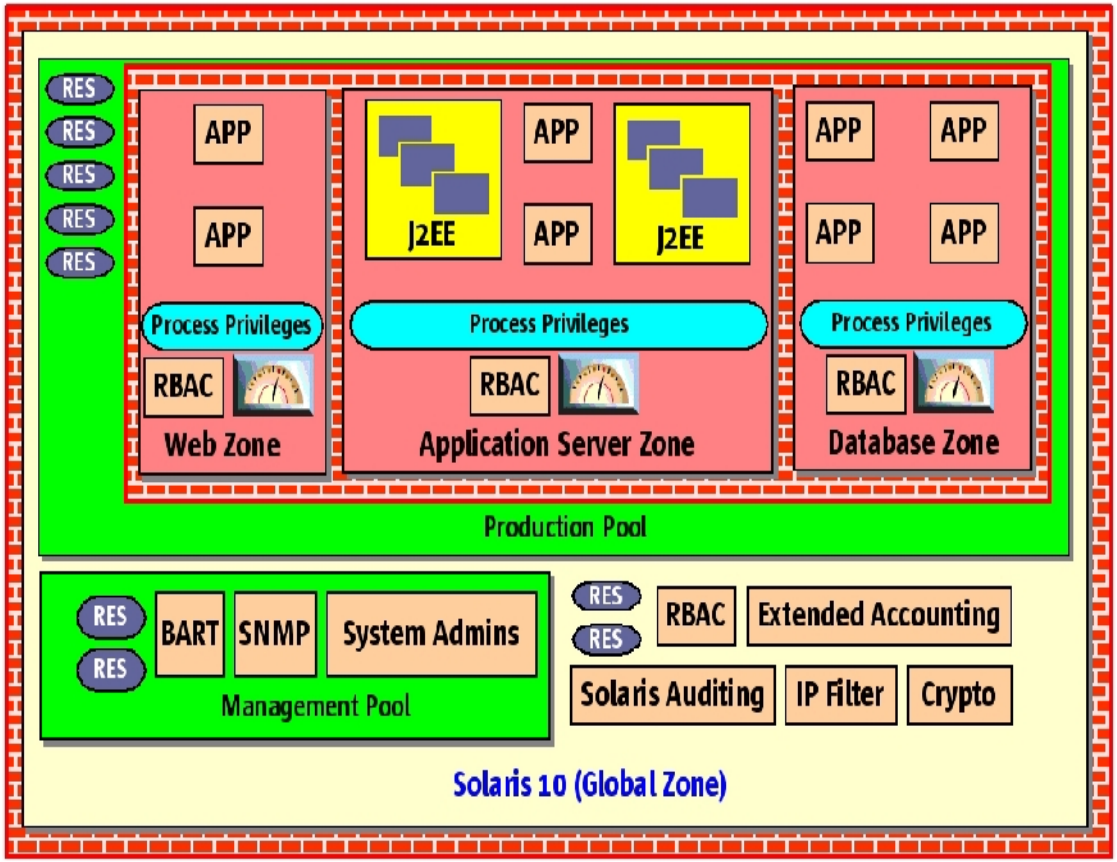
Kerberos Ecosystem Progress



Putting It All Together

Solaris 10 Security – A Secure Foundation for Success:

- Reduced Networking Meta Cluster
- Signed Binary Execution
- Solaris Security Toolkit
- Secure Service Management
- User Rights Management
- Process Rights Management
- Resource Management
- Kerberos, SSH, IPsec
- Cryptographic Framework
- Containers / Zones
- IP Filter, TCP Wrappers
- Auditing, BART



But wait! There's more!

- Auditing Improvements
  - Remote Logging via syslog
  - Audit Trail XML Translation
  - Audit Trail Noise Reduction
  - Audit Event Reclassification
- Enhanced TCP Wrappers Support
  - Now integrated with rpcbind and sendmail
- New Mount Options
  - noexec, nodevices
- User Process Visibility Restrictions
- vacation(1) Mail Filtering

and more...

- “root” GID is now “0” (root) not “1” (other)
- IPsec NAT Traversal
- RIPv2 Protocol Support
- ip_respond_to_timestamp now “0”.
- find(1) Support for ACLs
- “death by rm” safety
- OpenSSL libraries with a PKCS#11 engine
- Hardware RNG using Crypto Framework
- open(2) [O_NOFOLLOW], getpeerucred(3c), and many other developer enhancements...

and more...

- NFSv4
  - Support for GSS_API, ACLs, etc.
- Sendmail 8.13
  - Support for rate limiting and milters.
- BIND 9
  - DNSSEC, Views, IPv6 Support
- Java 1.5 Security
  - Security tokens, better support for more security standards (SASL, OCSP, TSP), various crypto and GSS security enhancements, etc.

... and the list keep right on going...

OpenSolaris (as of January 10, 2006)

- ZFS
- Cryptographic Framework Metaslot (S10U1)
- Kernel SSL Proxy
- IKE Support for NAT-T (RFC 3947 and RFC 3948) (S10U1)
- Randomized TCP/UDP Ephemeral Port Selection
- Persistent Static Routes
- Kerberos Credentials Auto-Renew Option
- Sendmail TLS Support (S10U1)
- elfsign(1) Token Support

Summary

- Solaris security is very strong...
  - A 20 year history of continuous improvement.
  - Getting safer, simpler and better each day.
- Requested Actions:
  - Evaluate Solaris 10 Today!
    - Try these new features and capabilities for yourself!
  - Consider a Solaris 10 Proof of Concept!
    - Let us help you realize all of the benefits of the Solaris 10 OS (security and otherwise!)
  - Please Give Us Feedback!
    - Tell us what you like, what you don't and where you think Solaris can be improved (and how)!

Solaris 10 Security Information

- Solaris 10 Home
  - http://www.sun.com/software/solaris/10/
- Solaris 10 Security Article
  - http://www.securityfocus.com/infocus/1776
- Solaris 10 Product Documentation
  - http://docs.sun.com/db/prod/solaris.10#hic
- Solaris 10 Security Blog Articles
  - http://blogs.sun.com/gbrunett
  - http://blogs.sun.com/casper
  - http://blogs.sun.com/arunpn
  - ... and many others...

General Security Information

- Sun Security Home Page
  - http://www.sun.com/security/
- Solaris Patches & Fingerprint Database
  - http://sunsolve.sun.com/
- Sun Security Coordination Team
  - http://sunsolve.sun.com/security/
- Sun BluePrints for Security
  - http://www.sun.com/security/blueprints/
- Solaris Security Toolkit
  - http://www.sun.com/security/jass/

Related Service Information

- Sun Client Solutions Security Services
  - http://www.sun.com/service/sunps/security
- Sun Education Security Services
  - http://suned.sun.com/US/catalog
- Sun Support Services
  - http://www.sun.com/service/support
- Sun Managed Security Services
  - http://www.sun.com/service/managedservices/

Solaris 10 Security

Deep Dive

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