Cisco Wide Area Application Services (WAAS) Technical Overview

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Agenda

- Enterprise Application Delivery Challenges
- Introducing Cisco Wide Area Application Services
- Cisco WAAS Product Architecture
- Citrix ICA Optimization
- Application Specific Optimization
- WAAS Express
- Virtual WAAS
- Network-embedded Virtualization
- Management and WAVE Platforms
- Summary
Disruptive Trends Drive New Needs

**Datacenter Transformation**
- Virtualization
- Private/Public Clouds
- Software-as-a-Service

**New Applications/Services**
- Rich Media, Video
- Any-any collaboration
- Virtual Desktops

**Remote Access Evolution**
- Increased mobile users
- ‘Low-footprint’ branches
- Partner access

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Customers / Partners

xAAS - Cloud

New IT and WAN Optimization Requirements

DC Apps & Data  Guest Users  Campus

Home Office/ Coffee Shop

Branch Office

Branch Office

DR Site

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Application Delivery Challenges

• Applications perform well in LAN
  High bandwidth
  Low latency
  Reliability

• Applications perform poorly in WAN
  Already congested
  Low bandwidth
  Latency
  Packet Loss
Introducing Cisco WAAS
Cisco WAAS: Comprehensive Portfolio

WAAS Appliance
- Application acceleration
- Virtual blades in branch offices
- Scalable platforms for range of deployments

AppNav
- Virtualize WAN optimization resources into pools of elastic resources
- Deployed in-path or Out of path to scale up to 8 AppNav modules & 32 WAAS or vWAAS Appliances.

WAAS Service Ready Engine
- Integrated ISR G2
- Application Acceleration
- Software on-demand provisioning
- No fork lift upgrade

Virtual WAAS
- Application acceleration from Private/Virtual Private Cloud
- VMWare ESX/ESXi and UCS deployments
- Agile, elastic, multi-tenant deployment
- vCM: common virtualized management for physical/virtual WAAS

WAAS Mobile
- Specifically Designed for Mobile Users
- Optimized for a single user
- Application Specific Optimizers

WAAS Express
- Integrated ISR G2
- On-demand IOS-based
- Bandwidth optimization
- Inline IOS features (Security, QoS)
- Small footprint, Cost-effective, Single CLI
Industry’s Most Comprehensive WAN Optimization Solution

Cloud-Ready vWAAS

Flexible Deployment WAAS Appliances

On-Demand via S/W WAAS ISR Modules

Native in IOS WAAS Express

Anywhere Access WAAS Mobile

Tele Worker Low Density Branch Retail Office
Large Branch, Regional Office Regional Office, Commercial Head End Data Center Head End, Regional Hub Large Enterprise /SP DC & High Performance DC-DC

Branch Config DC/Cloud Configs

WAVE-294 WAVE-594 WAVE-694 WAVE-7541 WAVE-7571 WAVE-8541

SM-SRE-710 SM-SRE-910

890 1941/2901 29xx 39xx

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Cisco SRE x86 Blade Server
Compact, multi-purpose blade housed in ISR G2

- 4GB and 8GB DRAM options
- Maximum 50W power draw 85% less than server
- Intel single and dual core 64-bit CPU options with virtualization extensions
- One external and two internal GE ports with TCP/IP acceleration
- USB 2.0 port for external device connectivity
- Wire-free, plug-and-play modularity, low shipping weight (2.5lb/1.1kg)
- Single and multi-blade provisioning and configuration through IMC Express
- One and two 500GB 2.5" HDD options with field-replacement protection
- Non-RAID, RAID 0, and RAID 1 configuration options with hot-swap capability
- Remote and schedulable power management
- iSCSI initiator hardware offload
- One and two 500GB 2.5" HDD options with field-replacement protection
- Single and multi-blade provisioning and configuration through IMC Express
- One and two 500GB 2.5" HDD options with field-replacement protection
- Non-RAID, RAID 0, and RAID 1 configuration options with hot-swap capability

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Cisco ISR G2 as Blade Server Enclosure
Use Slots on Most Widely Deployed Branch Device

- Secure platform with small attack surface
- Redundant power supply options
- Direct SRE blade to LAN connectivity
- Long service life 2x typical blade system

1, 2, 4 blade slots options

2 and 3 RU options

All-in-One Device for Branch Services

- WAN Optimization
- Wireless LAN/WAN
- Routing/Switching
- Application Hosting
- Unified Communications
- Security
Cisco WAAS Architecture

Platform Management and Services

- SMB2/ CIFS AO
- eMAPI AO
- HTTP AO
- SSL AO
- Video AO
- ICA AO
- NFS AO

TCP Proxy with Scheduler Optimizer (SO)
DRE, LZ, TFO

Cisco WAAS Operating System
Policy Engine, Filter-Bypass, Egress Method, Directed Mode, Auto-Discovery

Linux Kernel

Disk Storage (Cache, VB storage etc.)

- Multiple, Independent Processes
- Fault Isolation and Containment
Cisco WAAS Auto-Discovery

Solutions

- Devices automatically discover one another
- Devices automatically negotiate optimization capabilities

Benefits

- Eliminates need for complex overlay networks with tunnels
- And as the result reduces additional efforts associated with management, security and monitoring
WAAS TCP Flow Optimization (TFO)

Solution
1. Shorter/Better Slow Start
2. Improved Bandwidth Usage
3. Better Performance incase of High Packet Loss

Benefit
- Improved WAN BW utilization & app throughput
- End-nodes isolation of unruly WAN conditions
- LAN like TCP behavior due to TCP Proxy
Advanced Compression

**Solutions**
- Data Redundancy Elimination (DRE)
- Persistent LZ compression

**Benefits**
- New innovative context-aware DRE
- Up to 100:1 compression
- Session-based compression
- Up to an additional 10:1 compression even after DRE
Context-Aware DRE Summary

- Increased bandwidth savings through better compression
- Per branch fault isolation and protection

- Improve application performance on video, virtual desktops, SaaS
- Performance fairness across all branches
## Challenges
- Chatty Protocols
- WAN High Latency, High Packet Loss, Low Bandwidth ...

## Solutions
- Read-Ahead
- Asynchronous write
- DRE hints
- Meta-data caching
- Conetext - Aware DRE
- and more

### Applications
<table>
<thead>
<tr>
<th>Protocols</th>
<th>Typical Reduction</th>
<th>Maximum Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Sharing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIFS, NFS</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>Email</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exchange, OWA, Lotus Notes</td>
<td>75%</td>
<td>90%</td>
</tr>
<tr>
<td>Web Apps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTTP, HTTPS</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td>Software Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Center, Config. Mgr</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Enterprise Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsoft, Oracle, SAP, Documentum</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>Backup Apps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Center Data Protection Manager, Legato, Veritas</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>Data Replication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NetApp SnapMirror, Data Domain, Double Take, Veritas Vol Replicator</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>VDI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsoft RDP, Citrix ICA, VMWare View RDP</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Video, Video on Demand</td>
<td>90%</td>
<td>90%</td>
</tr>
</tbody>
</table>

## Broad Range of Applications
Fully Approved and Supported by Application Vendors
Seamless, Transparent and Secure Network Integration

- Compliance with critical network services such as:
  - Quality of Service (QoS)
  - Network Management
  - Application Performance
  - Security
  - Optimized Routing

- Disk Encryption
  - Mitigate concern of data theft
  - Standards-Based Strong Encryption (FIPS 140-2 level 2, 256-bit AES)
Simple Transparent In-path Deployment

✓ Plug-and-Play
  • No network changes
  • Mechanical fail-to-wire

✓ Scalability and High Availability
  • Up to 2
  • Redundant network paths & asymmetry
  • Load-sharing and fail-over

✓ Transparent Integration
  • Transparency and auto discovery
  • 802.1q VLAN trunking
  • All WAE appliances
  • Interception access list
Network-Integrated Off-path Interception

**WCCPv2**
- Active/active clustering
- Load redistribution
- Fail-over
- Fail-through operation
- Near-linear scalability & performance

**Policy Based Routing**
- Cisco WAE as a next-hop router
- Active/passive clustering

**WCCP variable timer**
- Configurable timeout (9, 15, 30 Sec)
- Default = 30 Sec (same as pre WAAS 4.4)

**WCCP L2 Egress**
- L2 Egress, WAAS remembers the source Router for every flow
- WAAS ensures as traffic leaves, it returns to the original router.
Cisco AppNav

AppNav gives the ability to **Virtualize** WAN optimization resources into **pools of elastic resources** with **business driven bindings**.

**Benefit**
- AppNav IOM contains it’s own network hardware, processing data independent of the WAVE Appliance.
- The host appliance for a AppNav module can still be used to optimize traffic.
- AppNav can scale up to 8 AppNav modules, along with 32 WAAS or vWAAS Appliances.
- AppNav can be deployed In-Path and Out-of-Path.
## AppNav Simplifies Service Insertion

**Easily Solve Deployment and Scalability Headaches**

<table>
<thead>
<tr>
<th>Deployment Consideration</th>
<th>In Path</th>
<th>Off Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Cable Insertion Outage</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>No Router / Switch Code Dependency</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>No Router / TCAM Impact</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Load and performance aware flow distribution</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Asymmetric flow support</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Inline Modes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel and Serial</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Ability to scale out / add capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constrained by Inline Device</td>
<td></td>
<td>Constrained by Router TCAM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AppNav (In Path)</th>
<th>AppNav (Off Path)</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Only Parallel Required
- N/A
- Constrained by Inline Device
- 10's of Gbps / Millions of Connections
Cisco AppNav Deployments (Inpath)

Today

With AppNav

- Investment protection
- Plug in AppNav IOM
- Simple to configure
- Flexible to deploy
- Scalable
- Native HA solution
- Asymmetry solution

Interception
Distribution
Scalability
HA & Asymmetry
WAAS Deployments (OffPath)

**Today**

- Scalable
- High Availability solution
- Asym. solution

**WCCP**
- ServiceGroup 61/62
- Calculate mask
- Plan for HA
- Plan for Asymmetry

**With AppNav**

- Investment protection
- Plug in AppNav IOM
- Light WCCP interception
- Scalable
- Non-disruptive capacity expansion and reduction
- Native High Availability
- Native Asym. handling

**Light WCCP**
- Single ServiceGroup
- Simple mask 0x01

**AppNav**
- AppNav cluster
- Policy based flow distribution

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Cisco AppNav interception and distribution

**Interception link**: intercept traffic from and to client
- **InPath** - two arms of bridge group
- **OffPath** – single arm

**Distribution link**: AppNav to AppNav/WAAS communication
- GRE encapsulated
- **InPath**: separate physical port than interception link
- **OffPath**: May be the same physical port as interception link
AppNav provides intelligent WAAS failure mitigation.

- On WAAS failure, AppNav maintain pre-existing TCP connections to other WAAS units.
- AppNav can also be configured with explicit backup HA units for critical devices.
- AppNav can also intelligently pass-through traffic if a failure would result in an overload condition for remaining units.
Automatic asymmetry handling via AppNav cluster

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forward path to WAAS through AppNav1</td>
</tr>
<tr>
<td>2</td>
<td>Flow updates between AppNav units</td>
</tr>
<tr>
<td>3</td>
<td>Reverse path to the WAAS through AppNav2</td>
</tr>
</tbody>
</table>

- Automatic asymmetry handling
- Maintains natural traffic path
- AppNav cluster – flow aware
Automatic asymmetry handling - Inter DC

- Automatic asymmetry handling
- Maintains natural traffic path
- AppNav cluster – flow aware
- Best Practice: local policy -> local WAAS
Citrix ICA Optimization
Poor Performance

- Choppy screen refreshes
- Application slowdown

Costly WAN Upgrades

- T1/E1 supports 5-10 users:
  - No bandwidth left for other applications, voice or video

Video Quality

- Poor user experience:
  - Low definition
  - Clogs the WAN

Multiple Vendors

- Expensive vendor coordination:
  - Storage
  - Servers
  - End-points
  - Network
Better Together

Enable Cisco Networks to become Citrix HDX-aware

Commitment for joint technology development reaching from data center to network to endpoints

Broad go-to-market partnership to deliver desktop virtualization solutions to customers
Cisco Wide Area Application Services
by Cisco Systems

Overview
Citrix Compatibility

Citrix Wide Area Application Services is verified to be compatible with:

<table>
<thead>
<tr>
<th>Citrix Product</th>
<th>Version</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>XenApp</td>
<td>5.0 32-bit</td>
<td></td>
</tr>
<tr>
<td>XenApp</td>
<td>6 64-bit</td>
<td></td>
</tr>
<tr>
<td>XenApp</td>
<td>6.5 64-bit</td>
<td></td>
</tr>
<tr>
<td>XenDesktop</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>XenDesktop</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>XenDesktop</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

http://www.citrix.com/ready/partners/cisco/products/cisco-waas
Native Optimization of Citrix XenDesktop and XenApp

Cisco WAAS offers automated interoperability with HDX and ICA

No changes to clients

No changes to servers

Branch Office

Data Center

High Performance Virtual Desktops
Cisco WAAS Optimized for Citrix
Seamless, Transparent Citrix Integration

- Seamless interoperability with existing Citrix infrastructure
- Requires no changes to XenDesktop or XenApp configuration
Understanding the Citrix ICA Handshake with WAAS

**WAAS acts as a transparent, trusted Man in the Middle**

- **Normal** to **Optimized** to **Normal**

**Transparent insertion into encrypted ICA/CGP communication.**

**WAAS applies TCP flow optimization to maximize bandwidth usage and mitigate packet loss.**

**WAAS applies inline compression algorithm over the optimized data, maximizing savings**

**WAAS delivers Citrix-aware multi-user Context-Aware Data Redundancy** that removes redundant data from across all end user connections.
Cisco WAAS Optimized for Citrix
Citrix-Aware Data Redundancy Elimination

Branch

Bi- and Uni-Directional Caches

Core Desktop Virtualization

Rich Media Virtual Desktops

USB / Disk Redirection

Data Center

Bi-Directional Cache

CAPACITY: Extra Free Space!

Performance Fairness for All Branches

✓ Increased bandwidth savings through better compression
✓ Directional data understanding allows for best performance

Save and Expand Caching Area

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Cisco WAAS Optimized for Citrix
Comprehensive Solution for End Users and IT Administrators

**Best User Experience**
- Up to 70% application acceleration
- Up to 90% video optimization
- Up to 95% print acceleration

**Fast and Simple**
- Zero server and client touch
- Supports existing Citrix Protocols – HDX and ICA, CGP, HTTP(S)
- Single solution for virtual and physical desktops

**Jointly Supported**
- Transparent insertion
- Validated and supported by Citrix and Cisco at time of availability
Application Specific Optimization
MAPI Application Optimizer

**Challenge**
- Uses MS-RPC - chatty protocol.
- Exchanges many interactive control messages.
- MAPI traffic is negotiated using MS Port Mapper (port 135) and is using dynamic ports.
- Data is encrypted between Client & Server.

**Solution**
- Encrypted MAPI support.
- Full application support.
- Asynchronous Writes.
- Read Ahead.
- Messages Decompression & Re-encryption.
- End to End Kerberos Authentication.

**Benefit**
- Maintain end to end application security for encrypted MAPI.
- Cleans up the outbox faster – important for cached mode users.
- Faster downloads of OAB, while significantly reducing BW consumption.
- Outlook 2000-2010 supported.
- Transparent, automatic optimization.
- No reverse engineering, fully supported by Microsoft.
- No security hole of keeping sessions open even after users have logged out.
Temporary keys allow access to Encrypt/Read/Sign Data

Securely transfer key to remote branch.

Trust Relationship Established

Request Key Exchange

Active Directory Controller (Kerberos KDC)

WAN-Secure

WAN

Application Data:
Optimized, Encrypted
Authentication:
Kerberos

Application Data:
Encrypted
Authentication:
Kerberos

Application Data:
Encrypted
Authentication:
Kerberos

Outlook Client

encrypted MAPI Request

Branch WAAS

Core WAAS

Exchange Server

How WAAS obtains permission to accelerate Encrypted Exchange
How Do I Establish Trust for WAAS in Active Directory?

WAAS needs to be configured with a read-only identity to obtain keys to encrypt, read, and sign data. WAAS supports two types of Active Directory identities:

Each Core WAAS device can join Active Directory as a “Workstation”

- Active Directory automatically performs password rotation for Workstation accounts

Or

Configure User Account(s) on each Core WAAS device

- A single user account can be used for all Core WAAS devices, if desired.
MAPI AO Read Ahead

Branch Office

Data Center

1. Read Read Response
2. Read Request Read Response
3. Read Response

WAN RTT Savings for subsequent requests
Faster Open, and Copy Operations

Local Read & Responses

READ AHEADS
MAPI AO - Asynchronous Write

1. Local Write & Responses
2. WAN RTT Savings for requests
   Faster write operations
3. Asynchronous writes
CIFS Application Optimizer: CIFS AO

Challenge
- CIFS is “Chatty” protocol
- WAN’s high latency, packet loss, and bandwidth constraints significantly diminishes Server access

Solution
- File and Metadata caching
- Read-ahead
- Message pipelining
- Scheduled preposition to pre-populate
- Transparent integration
- Dedicated CIFS cache

Benefit
- Enable consolidation of distributed file and print resources into the data center without compromising performance
- Offload of Data Center Servers

- 2MB Word document open, results in over 1000 message exchanges.
- 40ms RTT WAN, equates to more than 52 seconds of wait time before the document is usable
CIFS AO Read Ahead

1. First Pass: Read Ahead
   - Read
   - Read Response

2. Subsequent Requests: Serviced Locally
   - Read Request
   - Read Response

3. Local Read
   - Local Read & Responses

4. WAN RTT Savings for subsequent requests
   - Faster Open, and Copy Operations

5. READ AHEADS

6. Subsequent Requests: Serviced Locally

7. WAN RTT Savings for subsequent requests
   - Faster Open, and Copy Operations
CIFS AO - Asynchronous Write

1. Local Write & Responses
2. WAN RTT Savings for requests
   Faster write operations
3. Asynchronous writes
Addresses optimizations for deployments which require higher performance, client scaling, and optimization support for new variants of SMB protocol (v2.x) including SMBv2 Signing!

Enhanced to support high performance on low latency connection uses cases:

- Increase in memory storage vs. disk
- Latency: As low as 10ms and up
- WAN Throughput: Scale to 2.0 Gbps
# Microsoft File Sharing Feature Matrix

## WAAS 5.0 SMB / CIFS Application Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>SMB Application Optimizer</th>
<th>CIFS Application Optimizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimizes SMBv1 Traffic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optimizes CIFS Traffic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optimizes Print Traffic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optimizes Signed Traffic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optimizes SMBv2.x Traffic</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Native SMBv2.x Acceleration</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Performance tuned for High Throughput / Low Latency</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Supports Object Prepositioning</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Supports Advanced Print Acceleration</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

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Windows Printing Application Optimizer

**Challenge**
- MS Print protocol uses RPC - very "chatty"
- As a result over WAN it degrades exponentially as latency increases

**Solution**
- Based on licensed MS Print Protocols
- Optimized access to print queue status and printer settings
- Bi-directional Acceleration
- Printer and Queue meta-data caching
- Async write
- DRE hints for enhanced payload compression
- MS-RPC message optimization
- RPC command fragments handled asynchronously
- Delayed close of printer handles (OPEN requests local)

**Benefit**
- Users print at near-LAN speeds
- No need for Network IT group to manage Branch Print
- No configuration on WAAS – just turn it on!
- Enable scalable centralized Windows Print services
- Fully Transparent to Windows AD Management
- Easy server migration from branch to datacenter
NFSv3 Application Optimizer

**Challenge**
- In Unix, NFS protocol is used for large file exchange such as software builds, CAD applications and large directory access
- NFSv3 is a "chatty" RPC protocol
- Clients cannot efficiently operate on high-latency/high-bandwidth WANs

**Solution**
- Read-Ahead
- Asynchronous write
- DRE hints
- Meta-data caching

**Benefit**
- Can fill high-bandwidth links regardless of latency
- Transparent to client and server. No configuration required.
- Tested for compliance with IBM AIX, Linux and Solaris clients + Leading NAS vendors!

![Diagram showing original and optimized connections over a WAN](image)
## HTTP Application Optimizer

<table>
<thead>
<tr>
<th>Solution</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fast Connection Reuse</td>
<td>- Slow page load on Interactive Web applications</td>
</tr>
<tr>
<td>- Proxy Connect to SSL Servers</td>
<td>- Browsers serially open and close connections to fetch small objects (e.g. graphics)</td>
</tr>
<tr>
<td>- Local HTTP responses through Metadata cache</td>
<td>- Latency due to HTTP request/response</td>
</tr>
<tr>
<td>- Content-aware optimization</td>
<td></td>
</tr>
<tr>
<td>- DRE hints</td>
<td></td>
</tr>
<tr>
<td>- Server compression offload</td>
<td></td>
</tr>
</tbody>
</table>

### Benefit

- Mitigates latency due to HTTP request/response
- Fully transparent
- Reuse of same pair of client and server requests
- Compliments and preserves http application pipelining

---

![Diagram of HTTP Application Optimizer](image)

- Connect (SYN, SYN-ACK, ACK)
- HTTP Request
- HTTP Response
- Connect
Mitigate Latency using Local Response for Content Freshness Validation

1. GET logo.gif

2. 200 OK Etag: version1 Expires: 1 day

3. Expiry time cached by WAAS

4. GET logo.gif

5. 304 Not-Modified Etag: version1

Local Response: Freshness Info

WAN RTT Savings for subsequent requests
Improved Application Response Time across all clients
Browser Reload/Refresh

First Pass: Learning

Subsequent Requests: Serviced Locally
Mitigate Latency using Local Response for URL Redirect

1. GET www.cco.cisco.com
2. 301 Moved Permanently Location: www.cisco-cco.com
3. Old URL: www.cco.cisco.com
   New URL: : www.cisco-cco.com
4. GET www.cco.cisco.com
   Metadata Cache Hit!
5. 301 Moved Permanently Location: www.cisco-cco.com

WAN RTT Savings for subsequent requests
Improved Application Response Time across all clients
Mitigate Latency using Local Auth-Needed Response for URLs needing Authorization

1. Get Object #1

3. Notes authorization is required

4. Get Object #1 (Authorization: Basic (Username/Password))

5. 200 OK

6. Get Object #1

7. Metadata Cache Hit!

8. Get Object #1 (Authorization: Basic (Username/Password))

WAN RTT Savings for subsequent requests

Improved Application Response Time across all clients

Latency mitigation during morning rush
The Need for SSL Acceleration

- WAAS optimization benefits are maximized only when applied to decrypted payload
Cisco WAAS SSL Optimization Solution

- Core WAE acts as a Trusted Intermediary Node for SSL requests by client
- Private Key and Server Certificate are stored on the Core WAE device
- Core WAE participates in SSL Handshake to derive “session key”
- Distributes the “session key” securely in-band to the Edge WAE over the established connection between the Edge WAE and Core WAE

**Diagram:**

- **SSL Handshake:** Client & Core WAE
- **Edge WAE:**
  - Original Data - Encrypted
  - SSL Session Client to Core WAE (WAAS)
  - Transparent Secure Channel
  - Send “session key”
- **Core WAE:**
  - Original Data - Encrypted
  - SSL Session Core WAE to Server - Core WAE: Server Private Key
  - SSL Handshake
## Cisco WAAS SSL

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online Certificate Status Protocol (OCSP)</td>
<td>Real-time check whether SSL certificates are valid and/or revoked</td>
</tr>
<tr>
<td>Client Authentication</td>
<td>Server authenticates client based on client certificates. WAAS SSL can optimize traffic using client certificates</td>
</tr>
<tr>
<td>Explicit HTTP(S) Proxy</td>
<td>WAAS can optimization connections that upgrades from clear text to a crypto-SSL during connection set-up</td>
</tr>
<tr>
<td>Diffie-Hellman (DHE) Key Exchange</td>
<td>Higher Security Key Exchange Method</td>
</tr>
<tr>
<td>Simplified Group based Trust configuration</td>
<td>Automated trust relationship negotiation between WAAS devices using device group</td>
</tr>
<tr>
<td>HTTP Optimization techniques</td>
<td>Local HTTP responses through Metadata cache, DRE hints, server compression offload</td>
</tr>
</tbody>
</table>

### Benefit

- Maintains Trust Model in DC = Better Security
- Widest Range of SSL Acceleration
- Flexible Deployment
- Ease of Operation = Lower Opex

- Server key kept on core WAE
- Edge & core WAEs communicate securely
- OSCP
- Supports client authentication & validation
- PKI integration
- Wildcard Certificates signed by CA
- Enterprise CA signed Certificate
- SSL Service policy required only on the Core WAE
- Scalable service configuration using Wildcard certificates
Live Video Streaming with WAAS

Edge stream splitting

1. Uncompressed Video
   - Encoder
   - Microsoft Windows Media Server (WMS)
   - List of scheduled live streaming events

2. Click on published URL to get live stream
   - Web Portal
   - BRANCH OFFICE

3. Opens Windows Media Player
   - WAAS
   - WAN
   - Only one stream per remote site
   - auto-detect RTSP connections (no configuration required)

Note: Separate WAAS license for Windows Media Live Streaming required per contract w/Microsoft
**Video Application Optimizer**

<table>
<thead>
<tr>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Windows Media Stream Splitting</strong> - Each new client request (over LAN) will reuse existing incoming stream (over WAN) for the same stream URL</td>
</tr>
<tr>
<td><strong>Data-reduction and optimization for non-WMT/RTSP video</strong> – WAN optimization and bandwidth reduction for other video formats including video over HTTP, Flash, QuickTime, RealVideo, and any other video protocol that uses TCP as a transport</td>
</tr>
<tr>
<td><strong>Intelligent video server offload</strong> – Cisco WAAS video delivery services minimize the burden placed on the origin video server by intelligently</td>
</tr>
<tr>
<td><strong>RTSP/TCP rollover</strong> - Client requests over RTSP/UDP automatically rolled over to RTSP/TCP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WAN Bandwidth Savings</strong></td>
</tr>
<tr>
<td>➢ One video stream per remote site per webcast</td>
</tr>
<tr>
<td>➢ Edge-stream splitting serves users at site</td>
</tr>
<tr>
<td><strong>Leverage existing IP infrastructure</strong></td>
</tr>
<tr>
<td>➢ Multicast enabled networks not required</td>
</tr>
<tr>
<td>➢ Defer requirement for bandwidth upgrades</td>
</tr>
<tr>
<td><strong>Lower TCO</strong></td>
</tr>
<tr>
<td>➢ Reduce IT coordination needed for video apps (e.g. webcasting)</td>
</tr>
<tr>
<td>➢ Server Offload: Fewer Streaming Servers required in Data Center</td>
</tr>
<tr>
<td>➢ Lower Op-Ex: No configuration required (auto-detect live RTSP traffic)</td>
</tr>
</tbody>
</table>
WAAS-Express
Cisco WAAS Express
Extend Cisco WAAS product portfolio across ISR G2s

Simple
Cost Effective
Investment Protection

• 2X BW savings for SSL secured applications
  • Enables enterprise-wide delivery of broad range of applications
• Enhanced BW optimization and application performance visibility
  • No remote-office probe
• Save BW and remote office infra costs, while gaining greater application up-time with performance visibility

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WAAS Express Software Architecture

Select Application Acceleration
- Compression (LZ)
- Data Redundancy Elimination (DRE)
- TCP Flow Optimizations (TFO)

Unified Management
- Policy Engine
- TCP Proxy

CEF Interception and reinsertion

IOS Forwarding Path

L4: Throughput Optimization

Network Integration

Select Application Acceleration
Superior Bandwidth Optimization

DRE and LZ on Upload and Download

- Bi-Directional optimization enables better compression for typical branch office tasks
- Enabled by default, no configuration required.

Multiple / Backup WAN link support

- WAAS Express now supports Multiple WAN links.
- Per-TCP session load-sharing required.
- Asymmetric interfaces supported.
- Useful for failing to Backup WAN links.
Extended Optimization: HTTP Application Support

- Data Pattern Hints – Better performance, longer history.
- HTTP Mime/File Type Intelligence – Better latency reduction
- Suppress Server-Encoding – Better data reduction
Superior Bandwidth Optimization (cont.)

Extended Optimization: CIFS Application Support

- Data Pattern Hints – Better performance, longer history.
- File Type Intelligence, Read Ahead, Metadata Caching
- Targeted for inefficient CIFS / SMBv1 traffic
- Interoperates with WAAS appliance CIFS and SMB Optimizers
Encrypted Application Support

Support for Native SSL and HTTPS Web Applications

- Uses the proven and efficient Cisco WAAS SSL Infrastructure
- Enabled by default if SECK9 license is present.
- SSL Server Key and Certificates never need to be loaded in WAAS Express.
- Dynamic learning and forwarding of ephemeral SSL session keys from WAAS
- Simple configuration via the WAAS Central Manager
- Utilize Hardware processing on VPN-ISM module for higher performance (1941, 29xx, 39xx)
WAAS Express – Packaging & Licensing

- WAAS Express is a feature license which can be enabled with any technology package licenses
- Enforced using a license key
- License key enforcement done in IOS on the router using Cisco Software Licensing Infrastructure
- 60 day trial license available
- WAAS Express will not register with WAAS Central Manager unless valid and active license is present
- WAAS Central Manager will periodically ensure (trial and extension) license is active to allow customer configuration
# WAAS and WAAS Express feature comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Cisco WAAS</th>
<th>Cisco WAAS Express</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto Discovery of end nodes</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TFO (Transport Flow Optimization)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compression</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DRE (Data Redundancy Elimination)</td>
<td>- Disk based - Persistent</td>
<td>Memory based - non-persistent</td>
</tr>
<tr>
<td>Bandwidth Optimization for Secured Web (SSL)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Application Acceleration</td>
<td>✓</td>
<td>Selected file/web</td>
</tr>
<tr>
<td>Network Services Integration</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>WAAS Central Manager</td>
<td>✓</td>
<td>WAASx2.0: WCM5.0 WAASx1.0: WCM4.31+</td>
</tr>
<tr>
<td>WAAS Software compatibility</td>
<td>Cisco WAAS backward compatible</td>
<td>WAASx2.0: WAAS4.4.3c WAASx1.0: 4.2.1+</td>
</tr>
</tbody>
</table>
Embedded Performance Visibility

Cisco Performance Agent (PA) Response Time Monitoring reporting for WAAS Express

- No Agent to install – Router configuration only
- Available in Base IOS Router License
- Can export Application Response Time data to Cisco collectors and other 3rd party collectors - Netflow
- Cisco NAM 5.1 can display Application Response Time for WAAS & WAAS Express.
Virtual WAAS
Cisco vWAAS Accelerates Cloud Deployment

Accelerate cloud-bursting, workload mobility, virtualized deployment

Virtual Private Clouds

Enterprise A

Enterprise B

Private Cloud

Enterprise A

WAN

Branch Office

Challenges

- Access to Virtual Private Cloud
- Workload mobility
- Scale-out

Cisco WAAS Benefits

- Accelerate to VPC and other clouds
- Elastic multi-tenancy
- Policy based orchestration lowers opex

Mobile Users
Cisco vWAAS Provides Flexible Cloud Deployment Options

Private Cloud
- Traditional WAN Edge Deployment at Branch and DC
  - Gradual migration from Physical to Virtual
  - Multi-tenancy support

Private Cloud, Virtual Private Cloud, & Public Cloud
- Re-direction using vPath @VM level
- Elastic provisioning
- Multi-tenancy support
vWAAS vPATH Interception with Nexus 1000V

**Feature**

1. Optimization based on the port-profile policy in Nexus 1000V
2. New VM inherits policy
3. vPATH aware of VM mobility from one host to another
4. vWAAS DRE cache can be deployed in SAN

**Benefit**

1. On-Demand and elastic Orchestration
2. Application based interception
3. Fault Tolerant persistent performance
4. Multi-tenancy with flexible deployment
vWAAS Software Architecture

Platform Management and Services

- CIFS AO
- MAPI AO
- HTTP AO
- SSL AO
- Video AO
- NFS AO

TCP Proxy with Scheduler Optimizer (SO)
  DRE, LZ, TFO

VMware User Space vmTools

Configuration Management System (CMS)

Cisco WAAS Operating System
- Policy Engine, Filter-Bypass, Egress Method, Directed Mode,
- Auto-Discovery, drivers

VMWARE ESXi

Server HW (CPU, memory, Hard Disk (SAN/DAS))

Ethernet Network I/O
Network-Embedded Virtualization
Virtualized Application Delivery for Branch Office – Cisco WAAS Virtual Blade

- Centralize what you can with WAAS
- Locally host services (e.g. Windows Servers) on same WAAS device

Flexible, Optimized Branch IT

Data Center

Cisco WAAS Virtual Blade technology
Providing Best Mix of Distributed and Centralized IT Services
Validated by Microsoft for Windows Services
Virtual Blade Deployment

• Allocate resources and start Virtual-Blade instance
  Easy & Simple - from WAAS CM or from CLI
• Centrally deploy server image over to WAE
  From CLI or WAAS CM, using FTP or HTTP
Virtual Blade Offerings

• Broad range of services
  - Microsoft Windows Services (e.g. DNS, DHCP, SCCM)
  - Custom applications (internally developed)
  - Other applications (NAM, eCDS, Altiris)

• Improved performance, scale and usability
  - Multiple CPUs for VB (SMP) for higher compute performance
  - Network I/O Paravirtualization for higher network performance
  - Remote Network Boot Install (PXE) for agile provisioning

• Microsoft SVVP validated for Windows Server 2003, 2008 and 2008 R2
Microsoft and Cisco Solutions

**Microsoft Windows Server 2008 Server Core**
- Broad range of services (DNS, DHCP, SCCM, ...)

**Cisco WAAS with Virtualization**
- Complete WAN optimization + application acceleration
- SVVP certification on 2008 R2 (broader range of windows services)

**Cisco WAAS with pre-packaged Windows Server 2008 services**
- Joint architecture development
- Joint customer support
Windows Virtualization - Enabling Virtual On-Demand Service at the Branch

- **PreExecution Environment (PXE) client:** To fetches the image from the Boot Server

- **PV driver:** Efficient hardware access to Physical NIC, improves performance for custom applications requiring high network throughput
Management & WAVE Platform
Usability and scalability

- Single Point Configuration, Monitoring, and reporting
- HTML5 interface and charts,
- iPad Ready, no flash/apps required
- Device/system alarms + SNMP and syslog integration
- Platforms
  - WAAS appliances, WAAS Modules, WAAS Express 2.0, vWAAS
- SOA-ready Monitoring
  - Standard XML Web Service (SOAP)
  - Integration with external reporting and monitoring portals

High Availability

- Active/standby
- Automatic failover
- Config replication

Security

- HTTPS GUI and intra-device communication
- RBAC support
- Integrated IOS-like CLI accessible via SSH

Integrated Application Performance Monitoring

- Improved visibility to application performance
- Effective integrated Management & monitoring
- Rapid analysis of application performance issues
Enterprise Performance Monitoring Integration

- **Transparent Integration**
  - Packet header preservation
  - Enables visibility to end-nodes

- **Flow Export Agent**
  - Transmit accurate connection data to monitoring systems
  - Eliminates WOC distortion of TCP RTT analysis

- **Central Manager API**
  - Single view of Application Performance Management and Optimization

---

### Diagram

- **Remote Office**
- **TCP Flow Export Agent**
- **Cisco NAM**
- **WAAS CM**
Integrated Application Performance Monitoring

- Provide top talkers, network usage and application performance metrics before and after WAAS deployment, including WAAS Express
- Simplified configuration and monitoring workflow for Application Performance Monitoring
Cisco Performance Agent (PA) Reporting

- NAM extends visibility to remote sites with PA
  Integrated application performance and network usage statistics
  PA as a new data source

- Cisco PA available as software feature in base IOS image
  Available in 15.1(4)T
  Supported platforms - 880, 890, and ISR G2
## Cisco WAAS Express Sizing Recommendations

<table>
<thead>
<tr>
<th>Platform</th>
<th>Total DRAM Required</th>
<th>Maximum WAN bandwidth Supported</th>
<th>Recommended Number of Users</th>
<th>Max TCP Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>88x</td>
<td>768 M</td>
<td>1.5Mbps</td>
<td>1-10</td>
<td>75</td>
</tr>
<tr>
<td>89x</td>
<td>768 M</td>
<td>2 Mbps</td>
<td>1-10</td>
<td>75</td>
</tr>
<tr>
<td>1921*</td>
<td>512 M</td>
<td>512 Kbps</td>
<td>1 – 5</td>
<td>50</td>
</tr>
<tr>
<td>1941</td>
<td>2.5 G</td>
<td>4 Mbps</td>
<td>15-20</td>
<td>150</td>
</tr>
<tr>
<td>2901</td>
<td>2.5 G</td>
<td>6 Mbps</td>
<td>15-20</td>
<td>150</td>
</tr>
<tr>
<td>2911</td>
<td>2.5 G</td>
<td>6 Mbps</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>2921</td>
<td>2.5 G</td>
<td>6 Mbps</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>2951</td>
<td>4 G</td>
<td>6 Mbps</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>3925</td>
<td>4 G</td>
<td>10 Mbps</td>
<td>50</td>
<td>400</td>
</tr>
<tr>
<td>3945</td>
<td>4 G</td>
<td>10 Mbps</td>
<td>50</td>
<td>400</td>
</tr>
</tbody>
</table>

- **WAAS Express** requires maximum DRAM installed as indicated
- **Typical Interfaces** – 3G, T1, E1, Multi T1s, Multi E1s, and Serial
- **Performance Testing** Conducted with IOS FW, VPN (IPsec), NAT, and QoS

*1921 – no DRE support – only TFO/LZ, no additional memory required*
## Cisco WAAS Branch Platforms

<table>
<thead>
<tr>
<th>Hardware Configuration</th>
<th>Memory (GB)</th>
<th>Max Opt TCP Conn</th>
<th>Number of Virtual Blades</th>
<th>Drive (GB)</th>
<th>RAID</th>
<th>WAN Capacity (Mbps)</th>
<th>Connectivity Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>NME-WAE-302</td>
<td>.5</td>
<td>250</td>
<td>N/A</td>
<td>80</td>
<td>N/A</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>NME-WAE-502</td>
<td>1</td>
<td>400</td>
<td>N/A</td>
<td>120</td>
<td>N/A</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>NME-WAE-522</td>
<td>2</td>
<td>800</td>
<td>N/A</td>
<td>160</td>
<td>N/A</td>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td>SM-SRE-700/710</td>
<td>4</td>
<td>500</td>
<td>N/A</td>
<td>500</td>
<td>N/A</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>SM-SRE-900/910</td>
<td>4</td>
<td>1000</td>
<td>N/A</td>
<td>500</td>
<td>RAID-1</td>
<td>50</td>
<td>N/A</td>
</tr>
<tr>
<td>WAVE-294</td>
<td>4</td>
<td>200</td>
<td>2</td>
<td>250</td>
<td>N/A</td>
<td>10</td>
<td>4 port GE Cu</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>400</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>WAVE-594</td>
<td>8</td>
<td>750</td>
<td>2</td>
<td>500</td>
<td>Optional 2nd HDD for RAID1</td>
<td>50</td>
<td>8 port GE Cu</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>1,300</td>
<td>4</td>
<td></td>
<td>RAID-1</td>
<td>100</td>
<td>4 port GE fiber</td>
</tr>
<tr>
<td>WAVE-694</td>
<td>16</td>
<td>2,500</td>
<td>4</td>
<td>2x600</td>
<td>RAID-1</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>6,000</td>
<td>6</td>
<td></td>
<td></td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

* Final recommendations require a detailed sizing exercise that includes application traffic mix, traffic characteristics, application load and other factors mentioned in the sizing guidelines.*
# Cisco Data Center and Cloud Platforms

## Data Center

<table>
<thead>
<tr>
<th>Hardware Configuration</th>
<th>Memory (GB)</th>
<th>Max Opt TCP Conn</th>
<th>Drive (GB)</th>
<th>RAID</th>
<th>WAN Capacity (Mbps)</th>
<th>Connectivity Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAVE-7541</td>
<td>24</td>
<td>18,000</td>
<td>6 x 450</td>
<td>RAID-5</td>
<td>500</td>
<td>2 port 10GE SFP+</td>
</tr>
<tr>
<td>WAVE-7571</td>
<td>48</td>
<td>60,000</td>
<td>8 x 450</td>
<td>RAID-5</td>
<td>1,000</td>
<td>8 port GE Cu</td>
</tr>
<tr>
<td>WAVE-8541</td>
<td>96</td>
<td>150,000</td>
<td>8 x 600</td>
<td>RAID-5</td>
<td>2,000</td>
<td>4 port GE fiber</td>
</tr>
</tbody>
</table>

## Virtual WAAS (vWAAS)

<table>
<thead>
<tr>
<th>Model</th>
<th>MAX Devices</th>
<th>Virtual Cores</th>
<th>Memory GB</th>
<th>Hard Disk GB</th>
<th>WAAS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCM-100N</td>
<td>100</td>
<td>2</td>
<td>2</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>vCM-2000N</td>
<td>2000</td>
<td>4</td>
<td>8</td>
<td>600</td>
<td>694</td>
</tr>
</tbody>
</table>

Performance results based on Cisco UCS C210 M2 Cisco UCS B250 M2

<table>
<thead>
<tr>
<th>Model</th>
<th>OPT TCP Conn</th>
<th>WAN BW Mbps</th>
<th>Virtual Cores</th>
<th>Memory GB</th>
<th>Hard Disk GB</th>
<th>WAAS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>vWAAS-200</td>
<td>200</td>
<td>10</td>
<td>1</td>
<td>2</td>
<td>160</td>
<td>294</td>
</tr>
<tr>
<td>vWAAS-750</td>
<td>750</td>
<td>50</td>
<td>2</td>
<td>4</td>
<td>250</td>
<td>594</td>
</tr>
<tr>
<td>vWAAS-6000</td>
<td>6000</td>
<td>200</td>
<td>4</td>
<td>8</td>
<td>500</td>
<td>694</td>
</tr>
<tr>
<td>vWAAS-12000</td>
<td>12000</td>
<td>310</td>
<td>4</td>
<td>12</td>
<td>750</td>
<td>-</td>
</tr>
<tr>
<td>vWAAS-60000</td>
<td>60000</td>
<td>1000</td>
<td>8*</td>
<td>48</td>
<td>1500</td>
<td>7571</td>
</tr>
</tbody>
</table>
# WAAS High Performance Connectivity Options

<table>
<thead>
<tr>
<th>Module Type</th>
<th>Part Number</th>
<th>Inline Mode</th>
<th>Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 port 10GE Module</td>
<td>WAVE-10GE-2SFP</td>
<td>✓</td>
<td>SFP+ SR</td>
</tr>
<tr>
<td>4 port GE Cu Module</td>
<td>WAVE-INLN-GE-4T</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>8 port GE Cu Module</td>
<td>WAVE-INLN-GE-8T</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>4 port GE Fiber Module</td>
<td>WAVE-INLN-GE-4SX</td>
<td>✓</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Cisco AppNav Module

Cisco AppNav IOM:
12 x 1G copper
12 x 1G SFP

Cisco AppNav 1Gbps
Off path or in path deployment

Cisco AppNav 10Gbps
AppNav Off path deployment only appliance

4 x 10G SFP+

WAAS 5.0
Cisco WAVE:
- WAVE-8541
- WAVE-7571
- WAVE-7541
- WAVE-694

Cisco AppNav 10Gbps
AppNav Off path deployment only appliance

4 x 10G SFP+
## Cisco WAAS Mobile

### Mobile clients
- 10,000 Concurrent Mobile Clients
- Concurrent licensing: 30,000 – 40,000 end users

### Throughput
- 600 Mbps LAN-side
- 200 Mbps WAN-side
- 100,000 TCP connections
Summary

Cost Effective
- Most cost-effective
- Saves up to 40% over comparable
- Delivers operational flexibility at scale

Comprehensive
- Improves end user - application experience
- Only portfolio that fits every site
- Proven end-to-end architectural approach

Cloud Ready
- Starts with branch and consolidated data centers
- Transparently scaling to cloud & SaaS
Thank you.