White Paper

The Economic Benefits of a Cooperative Control Wireless LAN Architecture

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Introduction

The first wave of wireless LANs saw autonomous access points being deployed in key verticals such as healthcare, retail and manufacturing where there was overwhelming business advantage to having users and devices connecting to the network wirelessly. These autonomous (standalone or fat) access points were relatively simple to deploy but lacked the manageability, mobility, and security features that enterprises required, even for convenience networks. The lack of manageability and control increased the operational costs of these wireless LANs. The time associated with carrying out pre-installation site surveys, AP location tuning, periodic post-installation surveys and the per-AP configuration and image updating drove organizations to look for alternative solutions.

Centralized controller-based architectures emerged to address these issues and were able to add central management, allow fast device roaming, and provide coordinated RF management and security policies to these networks. Unfortunately, they also added the complexity of an overlay network and a tremendous increase in the capital cost of the solution. While being able to reduce the wireless LAN management costs, most controller-based solutions approach 2 times to 4 times the capital cost of a traditional autonomous AP deployment, especially when the environment is mission-critical and the need for redundant controllers is factored in to the equation.

Aerohive Networks cooperative control architecture is based on a new category of wireless infrastructure equipment called a Cooperative Control Access Point (CC-AP) which provides a simple and logical alternative for deploying wireless LAN infrastructures. A network based on Aerohive Networks cooperative control access points, called HiveAPs, can easily and cost-effectively be rolled out to support greenfield wireless LAN deployments, and can also provide a seamless upgrade for legacy autonomous access points, providing all of the benefits of a controller, without the need to add controllers or re-architect the network. The cooperative control functionality enables multiple HiveAPs to be organized into groups, called ”hives”, that share control information between HiveAPs to enable functions like fast layer 2 and layer 3 roaming, coordinated RF management, security, load balancing, high availability and mesh networking, allowing these functions to be provided in a controller-less architecture. Centralized configuration, monitoring and reporting is provided by a central network management system, called the HiveManager. This management appliance can be located anywhere within the network and is not essential to the network’s ongoing operation.

Cost Disadvantages of a Controller-based Wireless LAN Architecture

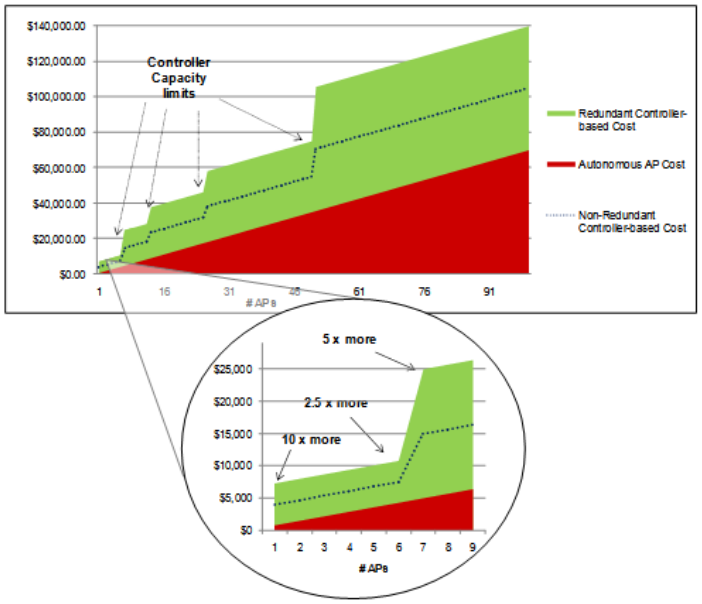
While there are definitely operational advantages associated with controller-based architectures over legacy autonomous architectures, there are numerous issues associated the controller-based architectures that increase the capital and long term business cost of the wireless LAN solution. They include:

- **Higher cost than comparable autonomous APs in all configurations**
  When controller-based architectures were first launched, expectations were that the thin APs that work with controllers would be significantly less expensive than traditional fat or autonomous APs, allowing the total capital cost of the solution to be competitive in spite of the added cost of the controllers. However this has not proven to be the case. So-called thin APs are increasingly needing to do more processing at the AP, and they are actually made with the same chipsets and components as fat APs, so their manufacturing costs – and in many cases their prices – are the same as autonomous APs. Because the controller-based solution requires that all packets be processed in two locations – the AP and the controller – the architecture requires twice as much hardware (mostly CPU and memory), which leads to approximately twice the cost, even in optimal configurations where controllers are fully loaded.

- **Stair-step solution cost curve – cost per AP increases if controllers aren't fully loaded**
  With controller-based architectures costs vary dramatically depending on the size of the controller and the degree to which you are able to, or want to, load the controller to its maximum AP capacity. Typically controller capacities don't align precisely with the topology required to support the unique configuration and RF characteristics of the floors and buildings an enterprise may be faced with. As a result real-world enterprise deployments rarely hit the sweet spot in the controller cost curve because the enterprise network manager ends up buying excess controller capacity and has to spread the major cost increases as he steps up to the next largest controller across a small number of APs.

- **Redundant controller costs**
  By design, the wireless LAN controller is the brains of a controller-based wireless LAN; it forwards all traffic and carries out all the control functions. In virtually all implementations, if the controller fails then all the access points stop functioning or have extremely limited capabilities. Thus the recommendation for all important or mission-critical implementations is that redundant controllers be deployed. This increases the network availability but also significantly increases the controller component of the solution cost.

Capital Cost per Site for Controller-based WLAN vs Autonomous AP WLAN



Example based on Cisco 1130 Series APs (running IOS or Autonomous mode) versus Cisco 1130 APs (running LWAPP) with Cisco 2006/2106 and 4400 Series controllers

- **Controller cost as a proportion of small site deployments**

Due to the controller-based solutions stair stepped cost curve discussed above, and poor controller capacity utilization when deploying branch office locations with a few APs, the cost can easily be several times higher than a traditional autonomous AP deployment. If a redundant controller is deployed for

high availability, the controller-based solution costs can be 2.5 to 5 or even 10 times higher than an autonomous AP solution in a small location.

- **Increased controller requirement to increase control and to reduce latency**
  Often in high capacity and mission-critical environments controllers are deployed closer to the access layer of the network to attempt to mitigate the performance and control problems caused by backhauling all of the traffic to a centrally located controller. This reduces the latency and jitter of the wireless LAN due to the reduced number of hops that the wireless traffic must traverse to and from the controller. It also means control decisions, like QoS, are being moved closer to edge. Reducing latency and jitter plus increasing the effectiveness of QoS ensures higher network and application performance. While this improves the operation of this architecture in mission-critical environments, it also requires that a larger number of smaller controllers is purchased and deployed, substantially driving up the cost of controller-based solutions.

- **Controller replacement due to capacity limits**
  As an enterprise adds a new application, such as voice over wireless LAN (VoWLAN) or migrates to 802.11n access points, the requirement for better performance and capacity increases and it is likely that the capacity of the original wireless LAN controller will be exceeded. In this case, additional controllers or larger replacement controllers will need to be deployed. Assuming the enterprise requires redundancy then this would require additional redundant controllers too. An example of this would be a branch office or retail location with four APs connected to a six-AP-controller needs to move to eight APs to achieve the desired AP density to improve RF coverage or handle the increased number of devices on the network as applications such as VoWLAN are implemented. This would require the addition of another six-AP-controller, not including the addition of any controllers for redundancy. If the network manager didn't want to manage multiple controllers in each branch, he might prefer to upgrade to a single larger controller capable of supporting the eight APs. But this is an expensive upgrade and it means that the existing controllers need to be discarded or redeployed.

- **Over-purchasing controller capacity**
  A third alternative for the scenario above is that the enterprise originally purchases larger controllers capable of supporting the future AP growth. In this case, assuming they purchased redundant controllers, then the customer only needs to purchase the additional APs that were required to provide the additional capacity. While this approach is effective from a future-proofing perspective, it will have a significant impact on the initial capital cost of the solution. The cost impact of this scenario will be especially significant when dealing with large numbers of APs or if this approach is applied to a distributed enterprise with a large number of branch or remote locations.

The Economic Benefits of a Cooperative Control Wireless LAN Architecture

Aerohive Networks cooperative control wireless LAN architecture provides an alternative that enjoys the simplicity and capital cost advantages of autonomous APs and the operational advantages of controller-based approaches. The key capabilities that deliver this include:

- **Centralized management and automated control functions**
  The manageability and the automated functionality of Aerohive Networks cooperative control architecture is able to address the management challenges associated with autonomous wireless LANs. Aerohive cooperative control wireless LAN functionality enables multiple HiveAPs to be organized into groups, called hives, that share control information between HiveAPs to enable functions like fast layer 2 and layer 3 roaming, coordinated RF management, security, load balancing, high availability and mesh networking. Centralized configuration, monitoring and reporting are provided by a central network management system, called the HiveManager. This management appliance can be located anywhere within the network and is not essential to the networks ongoing operation.

- **Linear cost structure and scalability**
  The linear cost model of the cooperative control architecture is able to ensure consistent and predictable costs when expanding coverage or adding capacity. Just by adding the appropriate number of HiveAPs, organizations are able to move from a convenience wireless LAN with meeting room coverage, to a mission-critical network, with whole site coverage and sufficient capacity for every employee to be wirelessly connected.

- **Inherent high availability**
  Typically the cost of redundant systems can have a huge impact on the overall wireless LAN solution cost, especially in large distributed enterprises with many branch or remote locations. The inherent stateful high availability and mesh redundancy of the Aerohive Networks approach is able to obviate the need to deploy redundant controllers. This high availability is able to be achieved using Aerohive Networks sophisticated wireless mesh, fast roaming, and best path forwarding capabilities. Together these features can allow the architecture to withstand multiple HiveAP outages and even a wired switch outage without the loss of wireless LAN service to the user.

- **Distributed control and forwarding**
  As previously discussed, controller costs can be many times the cost of the AP so any decision to increase the number of controllers deployed will dramatically impact the solution cost. Controllers are sometimes deployed closer to the access points to improve the capacity, latency, jitter, reliability and policy enforcement of the wireless LAN, increasing costs by requiring a larger number of smaller controllers. The distributed nature of Aerohive Networks cooperative control architecture eliminates the need to push

controllers closer to the edge to achieve these improvements, thus significant reducing the cost of a wireless LAN with these requirements.

- **No overlay network to manage**
  Due to Aerohive Networks cooperative control and best path forwarding there is no opaque overlay network created back to a wireless LAN controller, allowing existing network architecture, monitoring, QoS, and security systems to stay in place and continue to function in the same way that they had been prior to the introduction of the wireless LAN.

Example Deployment

The best way to demonstrate the economic benefits of Aerohive's cooperative control architecture is to work through a comparative deployment. Both wireless LAN controller-based solutions and Aerohive's cooperative control solution have considerable security, management and mobility advantages over autonomous based systems, with the management advantages considerably reducing the operational cost of the solution.

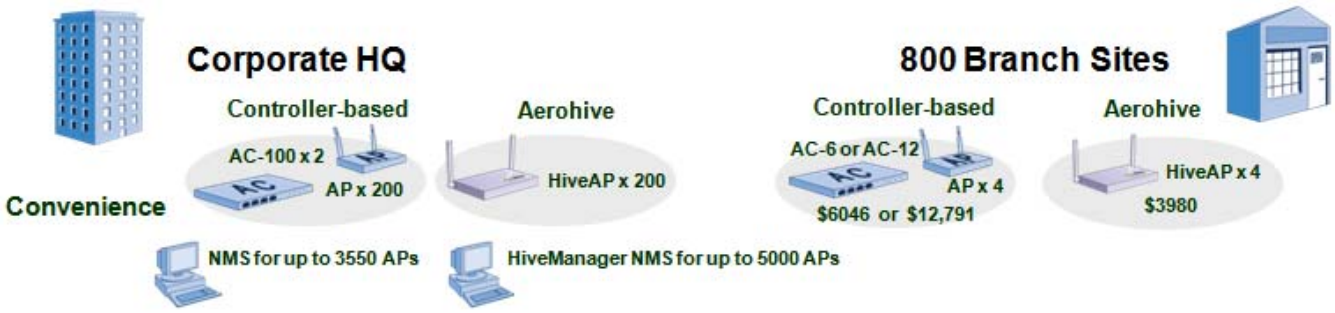
When comparing a controller-based solution to Aerohive's cooperative control solution the majority of the cost difference is in initial capital cost, the cost to add redundancy and to upgrade a network for greater capacity and control, where additional controllers are required or where increasing the number of APs drives a controller replacement due to capacity issues.

Let's look at a case study of a large enterprise with 800 remote sites that Aerohive is working with to deploy a wireless LAN solution that is cost effective today yet capable of evolving to support mission critical applications. While each vendor's specific pricing per controller and AP will vary, as will the capacity break points of controllers, the cost model for all controller-based solutions ends up being fairly similar. For the purpose of this case study the controller-based solution is based on the Cisco 2006/2106 and 4400 wireless LAN controllers and Cisco 1130AG Series APs.

The Cisco 1130AG Series AP priced at $699 is a lower-end AP than Aerohive's HiveAP 20 ag, but we are modeling the costs using the Cisco 1130 to be conservative. Cisco's more comparable hardware platforms are the Cisco 1230 or 1240 Series APs which cost considerably more, and would drive the solution costs up significantly.

Deploying on a Convenience Wireless LAN

In this example we start with a convenience network of two hundred (200) APs at the central site and four (4) APs at each of the remote sites.



	HQ Project Cost	
	Controller-based	Aerohive
Convenience	**$210K**	**$199K**
Total	**$210K**	**$199K**

Total Project Cost (HQ + Branch + NMS)	
Controller-based	Aerohive
$5.18M or $10.58M	**$3.57M**
$5.18M or $10.58M	**$3.57M**

The controller-based solution for the HQ location would consist of two hundred (200) thin APs @ $699 each + two (2) 100-AP controllers @ $34, 995 each for a total of $210K. Note that this is a best case scenario as these costs assume the HQ controllers are loaded to 100% of capacity and it assumes the use of the lower end Cisco 1130AG.

Depending on the expected growth plans for the branch wireless LANs, the enterprise has to choose between over-provisioning controller capacity by purchasing 12-AP controllers or utilizing the minimum required 6-AP controllers. Based on this decision the per branch solution for a controller-based deployment would be either:

i. four (4) thin APs @ $699 each + one (1) 6-AP controllers @ $3, 250 for a per branch total of $6,046, or
ii. four (4) thin APs @ $699 each + one (1) 12-AP controllers @ $9,995 for a per branch total of $12,791

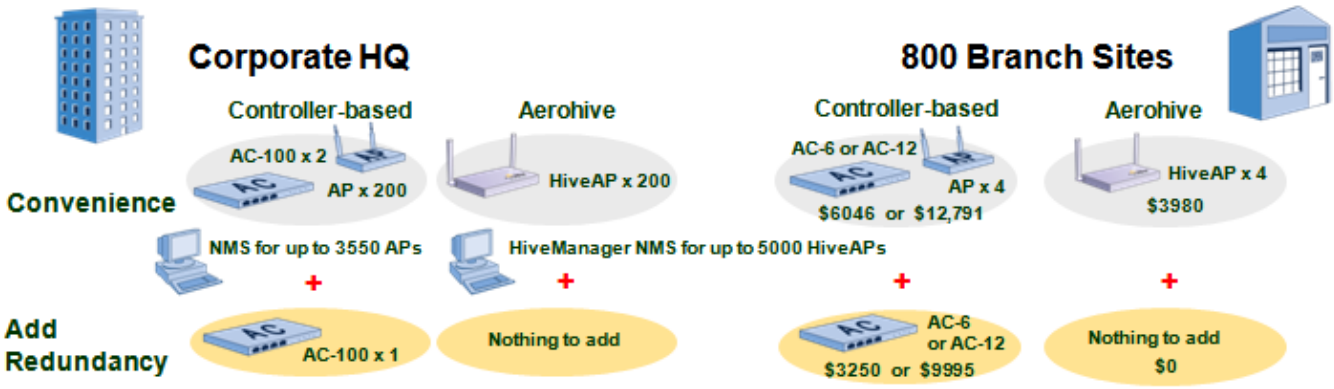
Including the cost of network management system (NMS) software capable of managing up to 3550 APs ($137K not including the cost of the server hardware) the total controller-based convenience wireless LAN cost would equal either **$5.18M** (800 x $6046 + $210K + $137K) or **$10.58M** (800 x $12,791 + $210K + $137K).

Aerohive's cooperative control solution for the HQ would consist of two hundred (200) HiveAPs @ $995 each for a total of $199K. Aerohive's branch solution would be four (4) HiveAPs @ $995 each for a per branch total of $3980.

Including the cost of a HiveManger NMS appliance capable of managing up to 5000 HiveAPs ($186K including the server appliance hardware) the total Aerohive convenience wireless LAN cost equals **$3.57M** (800 x $3980 + $199K + $186K).

Adding Redundancy

The first step to having a mission-critical wireless LAN network is making it highly available by adding redundancy.



	HQ Project Cost	
	Controller-based	Aerohive
Convenience	$210K	$199K
Add Redundancy	+$35K	+$0
Total	**$245K**	**$199K**

Total Project Cost (HQ + Branch + NMS)	
Controller-based	Aerohive
$5.18M or $10.58M	$3.57M
+$2.63M or $8.03M	+$0
$7.82M or $18.61M	**$3.57M**

In order to add redundancy to the controller-based solution an enterprise would need to either add a back-up controller for every controller in the network, or add a controller to back up all the controllers in a given location known as N+1 redundancy. This case study models the more cost conservative approach of N+1 although this approach can have additional technical limitations.

With a controller-based solution, adding redundancy at the HQ would require at least one (1) additional 100-AP controller which costs $35K. Depending on whether or not the enterprise decided to over-purchase controller capacity when they deployed their convenience wireless LAN, adding redundancy in each branch would require either:

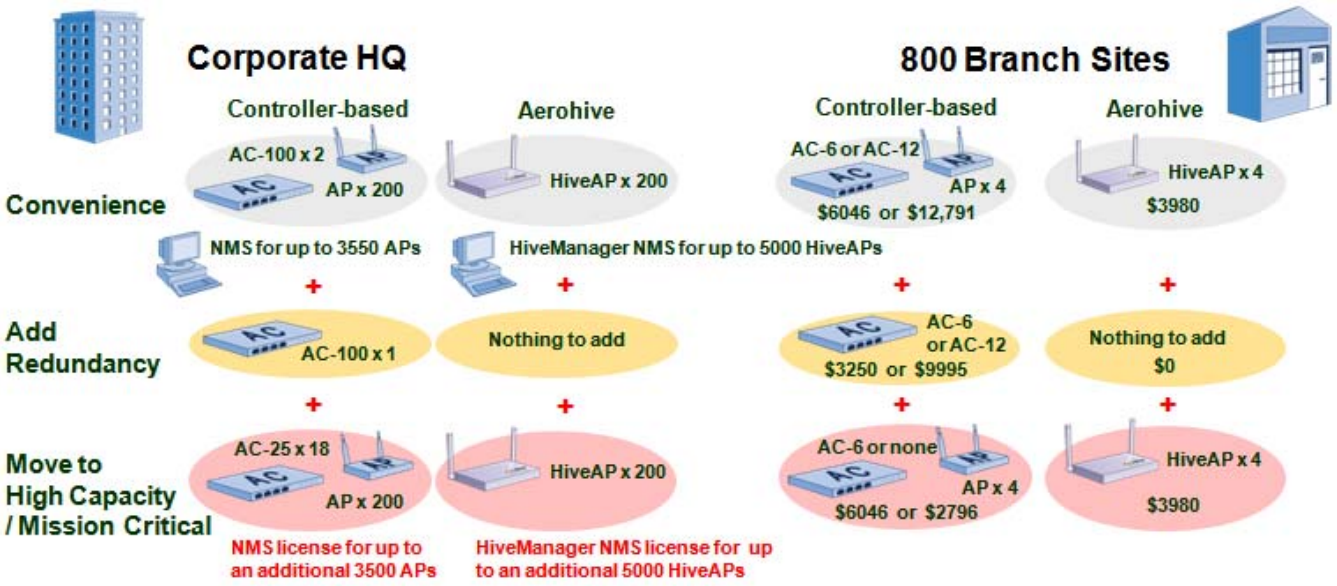
i. one (1) 6-AP controller @ $3, 250 per branch or
ii. one (1) 12-AP controller @ $9,995 per branch.

The total controller-based WLAN redundancy upgrade cost would equal either an additional **$2.63M** (800 x $3250 + $35K) or **$8.03M** (800 x $9,995 + $35K).

Due to the inherent redundancy in Aerohive's cooperative control wireless LAN architecture there is no additional cost for adding redundancy in the Aerohive solution.

Adding Capacity

The next step to make a wireless LAN network mission-critical is to ensure that the network has sufficient capacity to handle higher bandwidth applications, provide better RF coverage and support increased numbers of devices, such as VoWLAN handsets, connecting to the network. This is typically accomplished by increasing the AP density. In the case of the controller-based solution, increased control and capacity and reduced latency are also achieved by moving the controllers closer to APs. Moving controllers closer to the access layer like this results in a reduced number of APs per controller, and requires that many more smaller controllers are deployed.



	HQ Project Cost	
	Controller-based	Aerohive
Convenience	$210K	$199K
Add Redundancy	+ $35K	+ $0
High Capacity/ Mission Critical	+ $399K	+ $199K
Total	**$644K**	**$398K**

Total Project Cost (HQ + Branch + NMS)	
Controller-based	Aerohive
$5.18M or $10.58M	$3.57M
+ $2.63M or $8.03M	+ $0
+ $5.37M or $2.77M	+ $3.47M
$13.19M or $21.38M	**$7.04M**

In order to add controller capacity and double AP density at the HQ location, the incremental equipment required would be two hundred (200) thin APs @ $699 each + eighteen (18) 25-AP controllers @ $14, 395 for a total of $399K. This assumes that two of the 100-AP controllers would be lightly populated and redeployed into the access layer, with the third 100-AP controller providing N+1 redundancy for all 20 access layer controllers. This would result in an approximate AP to controller ratio of 20 APs per controller, with the 25-AP controllers being loaded at 80% of capacity.

Again, depending on whether or not the enterprise decided to over-purchase controller capacity up front, doubling the number of APs at the branch locations could pose a major challenge. If the enterprise initially chose to utilize 6-AP controllers for the branches then the addition of another four APs at each branch would exceed the capacity limits of the 6-AP controller and require that a third 6-AP controller be deployed. Two of these controllers would be used to support the APs and the third would provide redundancy in N+1 mode. This leaves the network operations team managing three controllers to support only eight APs. If the enterprise chose to over-purchase controller capacity in the beginning and buy the 12-AP controllers, then this capacity upgrade would only require the addition of the four APs per branch and their ongoing operations would be easier as they only need to manage two controllers per location.

So the branch capacity upgrade would consist of either:

i. four (4) thin APs @ $699 each + one (1) 6-AP controllers @ $3, 250 for a per branch total of $6,046 or
ii. four (4) thin APs @ $699 each for a per branch total of $2796

Including the NMS licensing cost to manage up to an additional 3500 APs ($133K) the total controller-based wireless LAN capacity upgrade cost would equal either an additional **$5.373M** (800 x $6046 + 399K + $133K) or **$2.77M** (800 x $2796 + $133K).

With Aerohive's solution that capacity increase at the HQ would only require two hundred (200) HiveAPs @ $995 each for a total of $199K. The branch capacity increase would require an additional four (4) HiveAPs @ $995 each per branch for a total of $3980 per branch.

Including the HiveManger NMS licensing cost to manage up to an additional 5000 HiveAPs ($90K) the total Aerohive WLAN capacity upgrade cost would equal **$3.47M** (800 x $3980 + $199K + $90K).

In this scenario the total cost to install a convenience network and to migrate to a mission-critical network would be **$7.04M** for an Aerohive solution and either **$13.19M** (87% more expensive) or **$21.38M** (200% more expensive) for the controller-based solution.

Of course not every enterprise has 800 remote locations like this company does, but the economic advantages seen in each location can accrue to any sized enterprise with multiple branches. The simple table below, which is based on the per branch total from the case study, shows the cost advantage of a cooperative control architecture for various numbers of branch offices that an enterprise may have.

# of branches	Controller-based - with initial purchase of small branch controller	Controller-based - with initial over purchase of larger branch controller	Aerohive cooperative control approach
10	**$153,420**	**$255,820**	**$79,600**
20	**$306,840**	**$511,640**	**$159,200**
50	**$767,100**	**$1,279,100**	**$398,000**
100	**$1,534,200**	**$2,558,200**	**$796,000**
200	**$3,068,400**	**$5,116,400**	**$1,592,000**
400	**$6,136,800**	**$10,232,800**	**$3,184,000**
800	**$12,273,600**	**$20,465,600**	**$6,368,000**

Conclusion

Aerohive Networks cooperative control architecture provides a simple and logical alternative for deploying wireless LAN infrastructures. The Aerohive Networks' approach provides a linear cost structure, automated control functions, distributed forwarding and high availability together with centralized management to reduce the overall cost of deploying and scaling both convenience-oriented and mission-critical wireless networks.