

# NETGEAR: Wireless N Performance Study

*Test report prepared under contract from NETGEAR*

## Executive Summary:

NETGEAR commissioned VeriTest, the testing service of Lionbridge Technologies Inc., to conduct a competitive analysis comparing the performance of wireless products from NETGEAR, Linksys, D-Link, and Belkin. We conducted a series of throughput tests, using Ixia IxChariot, to find which wireless products have the greatest throughput performance.

We conducted the testing in San Jose, CA in a cul-de-sac of a residential housing area. Tests included: Short, Medium, and Long range locations, with first and second story locations. We also tested in an outdoor location. The result for each test was calculated by averaging the consistent throughput values from multiple test runs.

In our study, we found that the NETGEAR's RangeMax™ NEXT Gigabit Edition demonstrated the greatest throughput of all of products that we tested. In our testing, the NETGEAR's RangeMax™ NEXT Gigabit Edition with RangeMax™ NEXT USB 2.0 adapter had twice the transfer speed than the competition. NETGEAR achieved the greatest short, medium, and long range throughput speeds of all of the products in our study. NETGEAR maintained a reliable connection during heavy interference and long range conditions.

## Key Findings

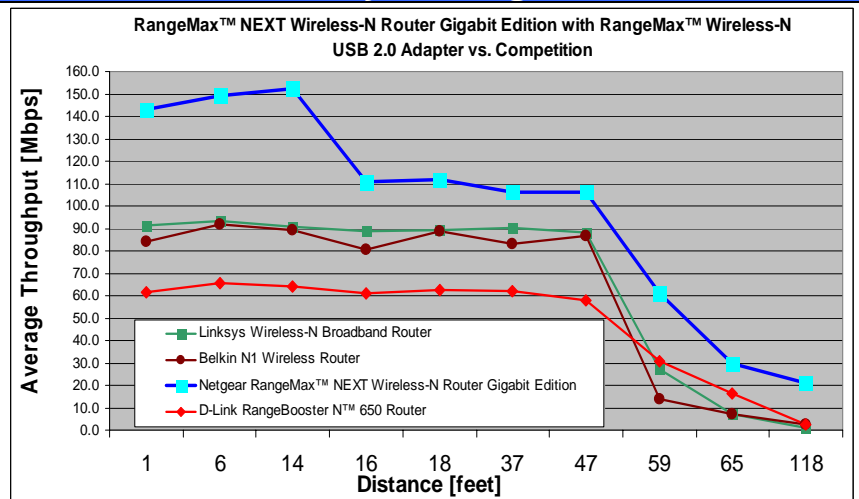


Figure 1: Average Upload Speed Chart.

### Key Findings:

- ❑ On average, NETGEAR's RangeMax™ NEXT Gigabit Edition with RangeMax™ NEXT USB 2.0 adapter configuration transferred up to 2x faster than the competition.
- ❑ NETGEAR achieved the strongest short, mid, and long range throughputs.
- ❑ NETGEAR maintained a strong and reliable connection in heavy interference or long range conditions.

## Testing Methodology:

NETGEAR commissioned VeriTest to conduct a competitive analysis comparing the performance of wireless configurations of products from NETGEAR, Linksys, D-Link, and Belkin. We conducted a series of throughput tests, using IxChariot, to find which wireless configuration had the greatest throughput performance. The following vendor products were tested under the same conditions with the same methodology. Additional information, such as test system configurations, can be found in the attached Excel sheet.

To execute the testing, we used two notebook systems running Windows XP with the latest version of the IxChariot benchmarking tool. Complete specification of the notebook systems can be found in Appendix A. We used IxChariot for testing at each of the 11 locations and 4 orientations. Details of these locations and orientations can be found in Figure 4-5. Before testing commenced, we set up the proper configuration in IxChariot using High-Performance/NDL files ranging from 100 kilobits to 10 megabits depending on which configuration showed the steadiest throughput, and at which range the testing was taking place. Consistent throughput (graphed inside IxChariot) was the main focus of testing because of the instability of an open environment such as, neighborhood wireless traffic, construction, or housing/landscaping, in which testing took place. Each Vendor's configuration was subject to the same consistent focus. Because results were based upon consistency, level throughput (graphed inside IxChariot), and expected result, values per degree were averaged from the 3 consistent values. (See the attached excel sheet for specific location/orientation results).

We tested the following wireless configurations:

### Linksys:

- WRT300N Wireless-N Broadband Router with WPC300N Wireless-N Notebook Adapter (with and without two-end points)
- WAG300N Wireless-N ADSL2+ Router with WPC300N Wireless-N card

### Belkin:

- N1 Wireless Router F5D8231-4 with N1 Wireless Notebook Card F5D8011

### D-Link:

- DIR-635 Range Booster N Router with DWA-642 Range Booster N Notebook Adapter

### NETGEAR:

- NETGEAR: RangeMax™ NEXT Wireless-N ADSL2+Modem router (DG834N) with RangeMax NEXT Wireless-N Notebook Adapter (WN511B).
- NETGEAR: RangeMax™ NEXT Wireless-N Router Gigabit Edition (WNR854T) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).
- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N Notebook Adapter (WN511B).
- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834M) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).
- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N Notebook Adapter (WN511B) – With and Without Security enabled.
- NETGEAR: 54 Mbps Wireless Router (WGR614) with NETGEAR 54 Mbps Wireless PC Card 32-bit Card Bus (WG511).



## Locations Specifications:

Location #	Location description (interference, story, ft. away from router).
1. Bedroom North	1st story, Line of sight (1 foot away from router).
2. Bedroom North	1st story, Line of sight (6 feet away from router).
3. Guest Room East	1st story, 1.5 sheetrock wall (14 feet away from router).
4. Bedroom West	2nd story, 1 level+1 sheetrock wall (16 feet away from router).
5. Master Bedroom East	2nd story, 1 level+1.5 sheetrock wall (18 feet away from router).
6. Living Room	1st story, about 3.5 sheetrock walls (37 feet away from router).
7. Kitchen	1st story, about 5 sheetrock walls (47 feet away from router).
8. Garage	1st story, about 6 sheetrock walls (59 feet away from router).
9. Outdoor behind Garage	1st story, 1 level + about 6 sheet rock walls+ 1 ext wall (65 feet away from router).
10. Outdoor front	Mid street, 1.5 sheet rock walls + 1ext wall+ trees/fence shadowing (118 feet away from the router).
11. Outdoor Xing with Calle Margarita	1.5 sheet rock wall + 1 ext wall + trees/fence/garden house shadowing (142 feet away from router).

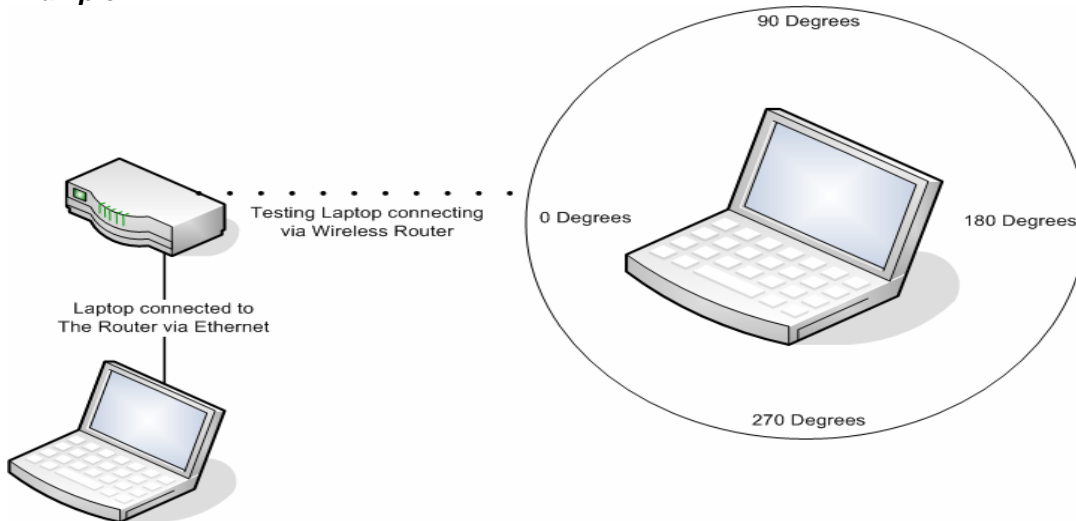
**Figure 2: Location Specifications**

## Orientation Specifications:

Each location received 4 points of testing based on a scale of degree.

- 0 Degrees (Card bus or USB Dongle facing towards the router).
- 90 Degrees (90 degree turn from the 0 degree).
- 180 Degrees (90 degree turn from the 90 degree).
- 270 Degrees (90 degree turn from the 180 degree).

### Example:



**Figure 3: Testing Orientation**

## Throughput Testing:

NETGEAR commissioned VeriTest to conduct a competitive analysis comparing the performance of wireless configurations of products from NETGEAR, Linksys, D-Link, and Belkin. We conducted a series of Uplink throughput tests, using IxChariot, to find which wireless configuration had the greatest throughput performance.

This test consisted of an IxChariot script running High-Performance/NDL files with data transfer rate ranging from 1 Megabit to 10 Megabits from the mobile laptop endpoint, to the laptop stationary inside the room (Location 1) with the Router. The IxChariot script was configured once before testing for short to medium range testing, and then again before long range testing.

## Test Run Conditions:

To keep testing between Vendors from obtaining any advantages over each other based on location, orientation, it was required that the following conditions were met before testing could begin:

- Each computer must be placed in the same spot and follow the strict orientation guideline.
- Each configuration was pre-run in the first two locations to ensure the best and most efficient IxChariot script was used.
- Each computer must be running on a battery level of above 80% (for testing outside), and plugged into an outlet when testing inside.
- IBM built in wireless disabled/turned off.

There were many factors affecting actual throughput analysis such as structures, latency, network traffic, etc. Because these factors were out of our control and testing was not done in a controlled lab the exact results may not be reproducible. The tests were designed to be objective by ensuring that each Vendor configuration was affected by the same or similar environmental factors.

## Test Run Details:

The main focus of testing was to ensure that each vendor was receiving the most accurate results for that testing condition. Our first determinant was to pay strict attention to the throughput (graphed inside IxChariot). Next, we paid close attention to consistency to help weed out incongruencies and false throughput readings within our averaged values. Finally, the third variable to help determine what the final value (or expected result) should be, NETGEAR provided us with previous testing data. These findings were only referenced during initial discussion on setting up the test environment.

## Calculating Average:

When calculating throughput values, the three points of focus were followed:

- Consistency
- Steady Throughput (Graphed in IxChariot)
- Closest to expected result

After receiving an expected value that met those three conditions, we calculated and averaged the three highest values (that met the above mentioned conditions) to get the most accurate throughput value.



## Test Results:

Below are examples of some of the averaged throughputs that we received during testing. The graphs below are a few of the NETGEAR configurations graphed next to similar vendor configurations.

### RangeMax™ NEXT Wireless-N ADSL 2+ Modem Router Throughput

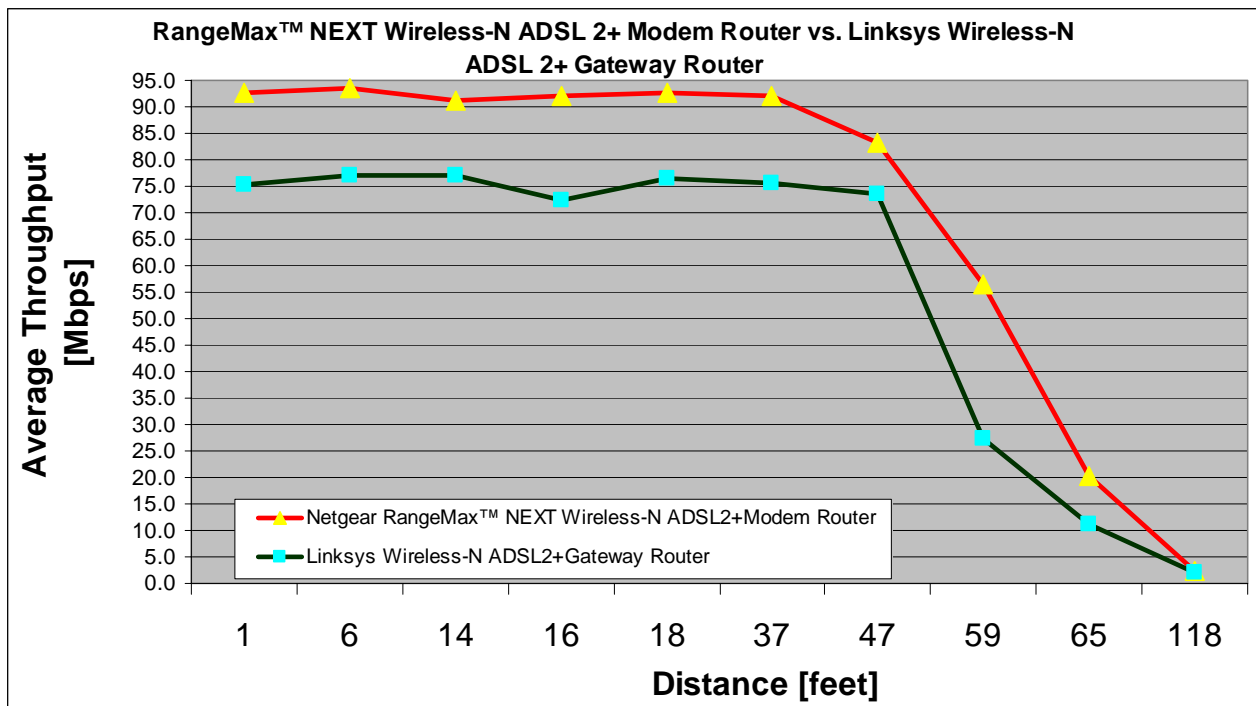


Figure 4: RangeMax™ NEXT Wireless-N ADSL 2+ Modem Router Throughput vs. Competition

## Key Findings:

- NETGEAR maintains high and stable throughput even at long distances.
- Competitor's throughput often becomes unstable or disconnects at long range with throughput reduced to zero.

## Figure 6: Configurations:

- NETGEAR: RangeMax™ NEXT Wireless-N ADSL2+Modem router (DG834N) with RangeMax NEXT Wireless-N Notebook Adapter (WN511B).
- Linksys: Wireless-N ADSL2+ Gateway Router (WAG300N) with Wireless-N Notebook Adapter (WPC300N).



## RangeMax™ NEXT Gigabit Edition with USB2.0 vs. Competition

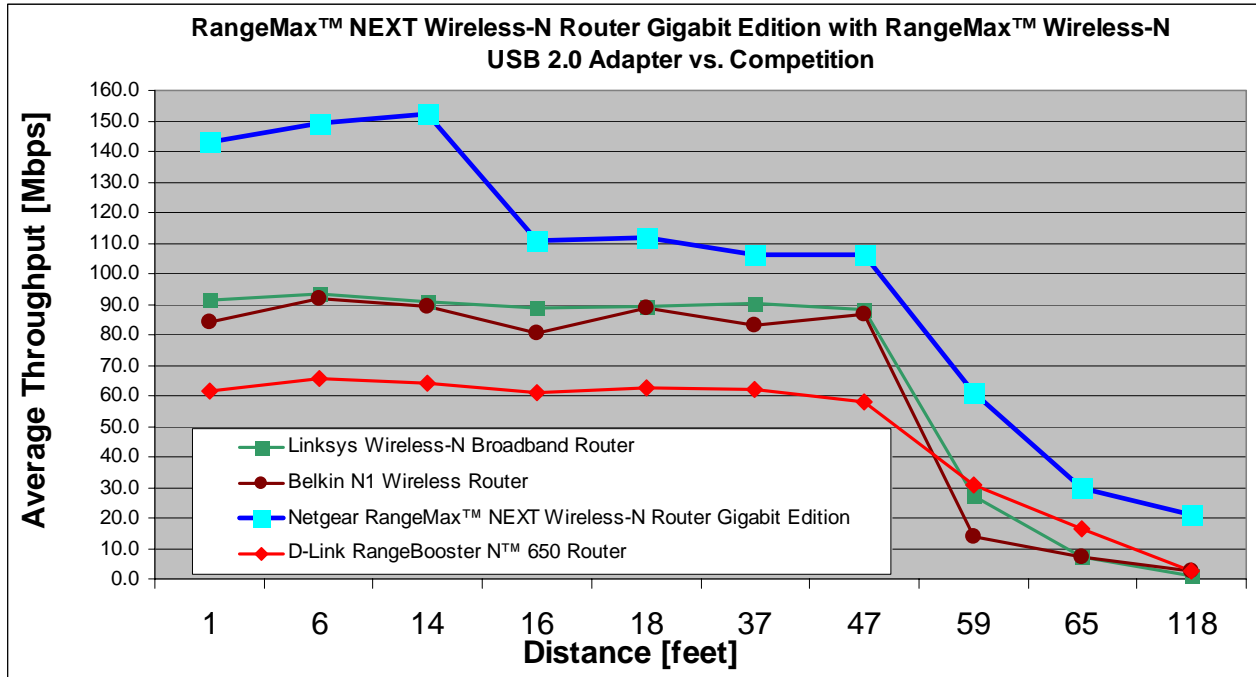


Figure 5: RangeMax™ NEXT Gigabit Edition with USB2.0 vs. Competition –Throughput

### Key Findings:

- ❑ Top performing NETGEAR Wireless-N Gigabit Router - Highest throughput compared to competition across every distance.
- ❑ NETGEAR maintained a strong and reliable connection in heavy interference or long range conditions.
- ❑ On average, NETGEAR's USB configuration transferred up to 2x faster than the competition.

### Figure 7: Configurations:

- ❑ Linksys: Wireless-N Broadband Router (WRT300N) with Linksys Wireless-N Notebook Adapter (WPC300N).
- ❑ Belkin: N1 Wireless Router (F5D8231-4) with N1 Wireless Notebook Card (F5D8011).
- ❑ NETGEAR: RangeMax™ NEXT Wireless-N Router Gigabit Edition (WNR854T) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).
- ❑ D-Link: RangeBooster N™ 650 Router (DIR-635) with D-Link RangeBooster N™ 650 Notebook Adapter (DWA-645).

## RangeMax™ NEXT Gigabit Edition with USB2.0 vs. Competition (Long Range)

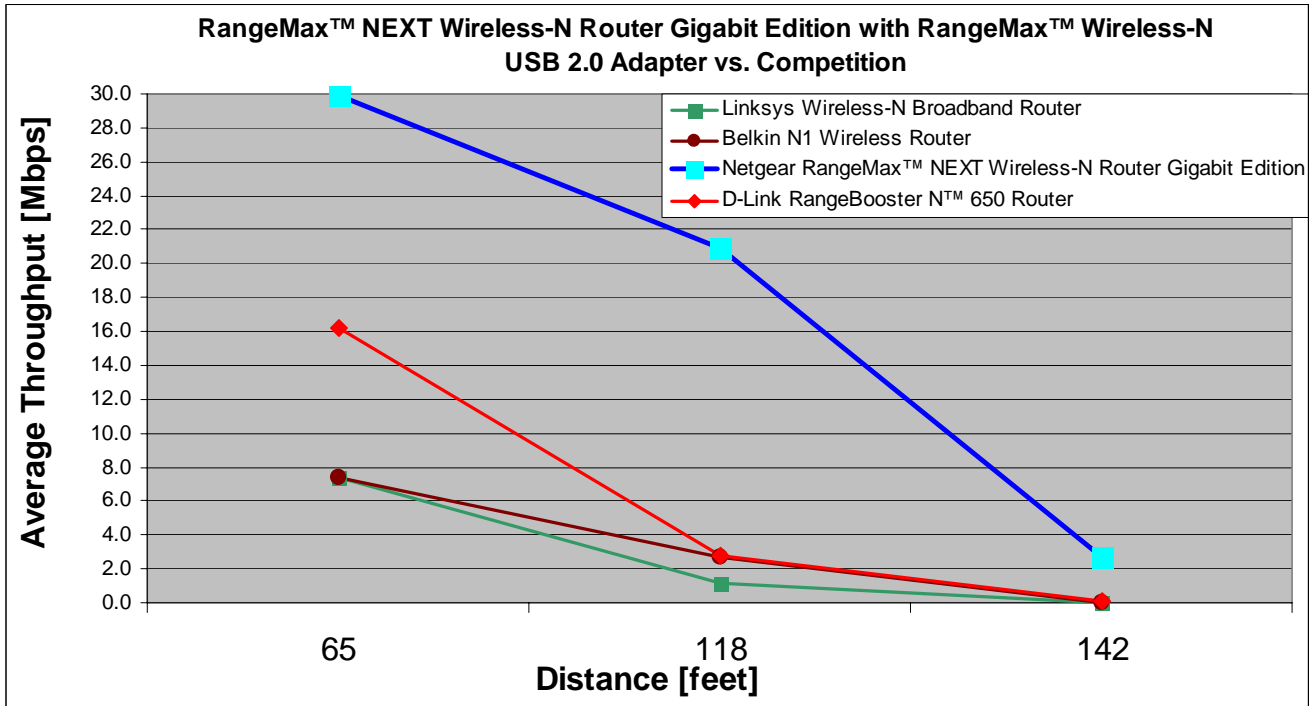


Figure 6: RangeMax™ NEXT Gigabit Edition with USB2.0 vs. Competition – Long range Throughput

### Key Findings:

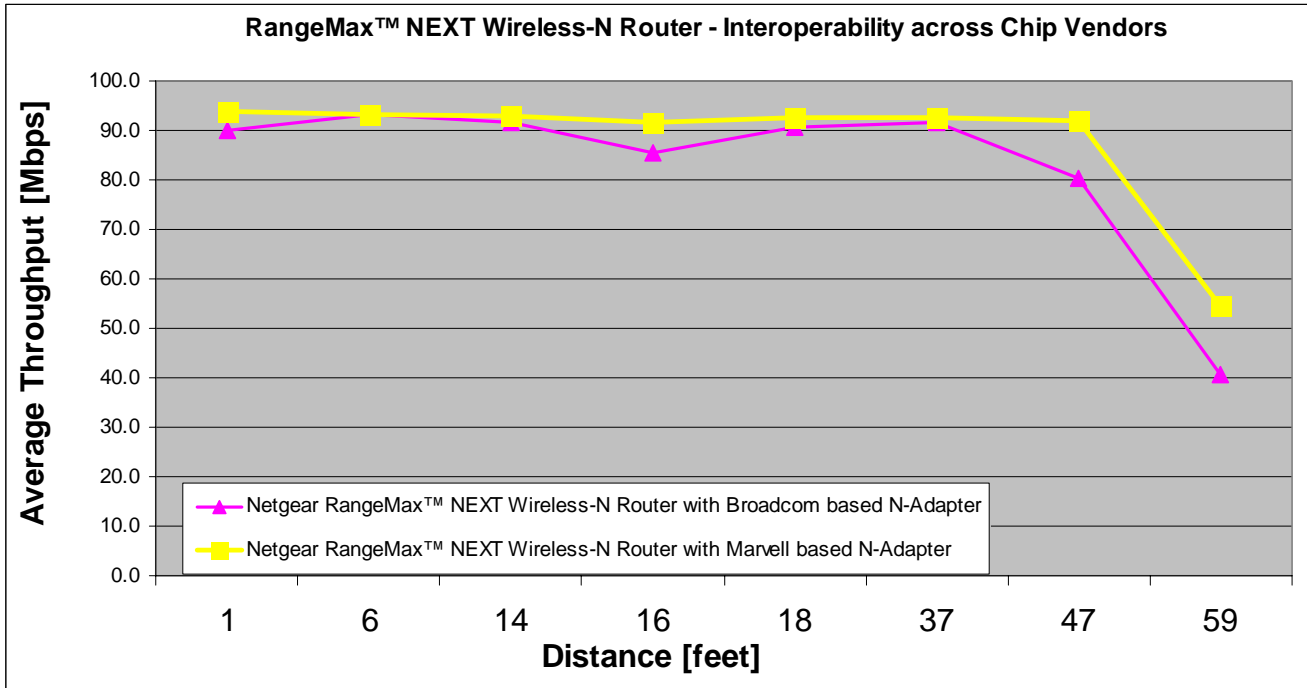
- ❑ NETGEAR maintains a high reliable throughput at long distances.
- ❑ Competitor's throughput becomes unstable or disconnects at long range with throughput reduced to zero.

### Figure 8: Configurations:

- ❑ Linksys: Wireless-N Broadband Router (WRT300N) with Linksys Wireless-N Notebook Adapter (WPC300N).
- ❑ Belkin: N1 Wireless Router (F5D8231-4) with N1 Wireless Notebook Card (F5D8011).
- ❑ NETGEAR: RangeMax™ NEXT Wireless-N Router Gigabit Edition (WNR854T) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).
- ❑ D-Link: RangeBooster N™ 650 Router (DIR-635) with D-Link RangeBooster N™ 650 Notebook Adapter (DWA-645).



**RangeMax™ NEXT Wireless-N Router - Interoperability across Chip Vendors:**



**Figure 7: Interoperability across Chip Vendors –Throughput**

**Key Findings:**

- ❑ NETGEAR's RangeMax™ NEXT Wireless-N routers interoperate with different Wireless-N adapters with different chipsets without compromising performance.

**Figure 9: Configurations:**

- ❑ (Broadcom Chipset - Purple) NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N Notebook Adapter (WN511B).
- ❑ (Marvell Chipset - Yellow) NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).



## RangeMax™ NEXT Wireless-N Router vs. Competition – Throughput

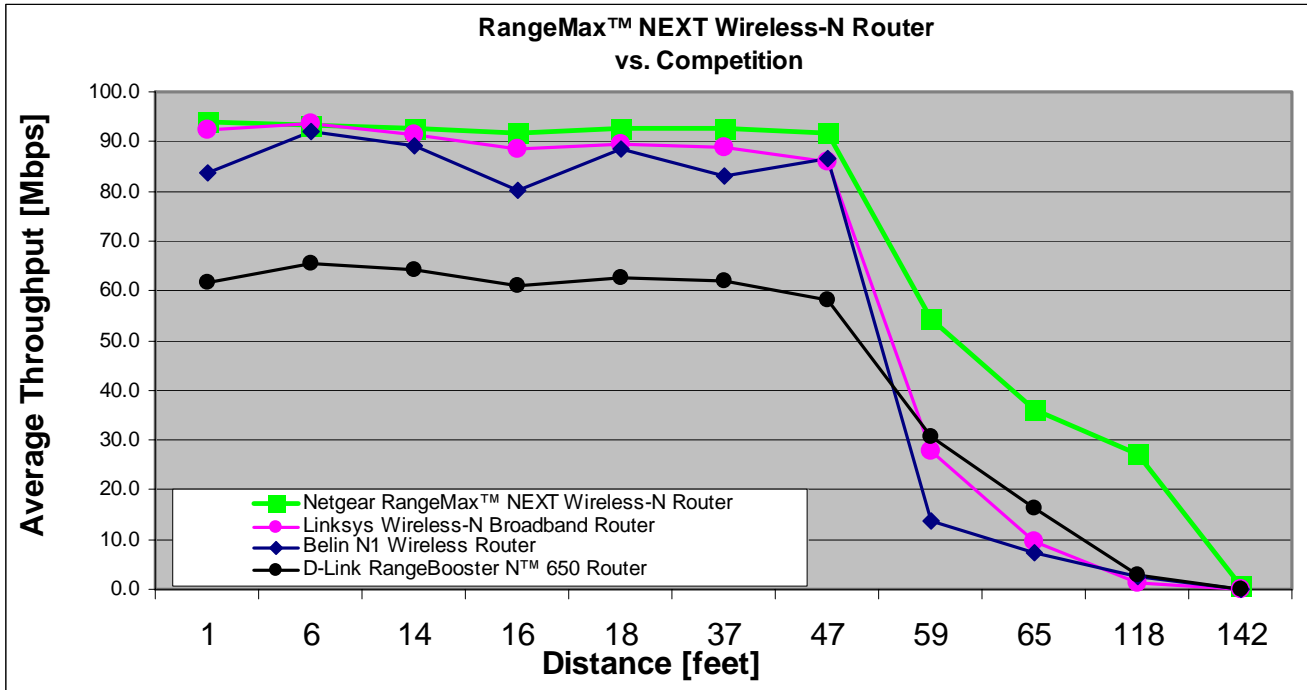


Figure 8: RangeMax™ NEXT Wireless-N Router vs. Competition - Throughput

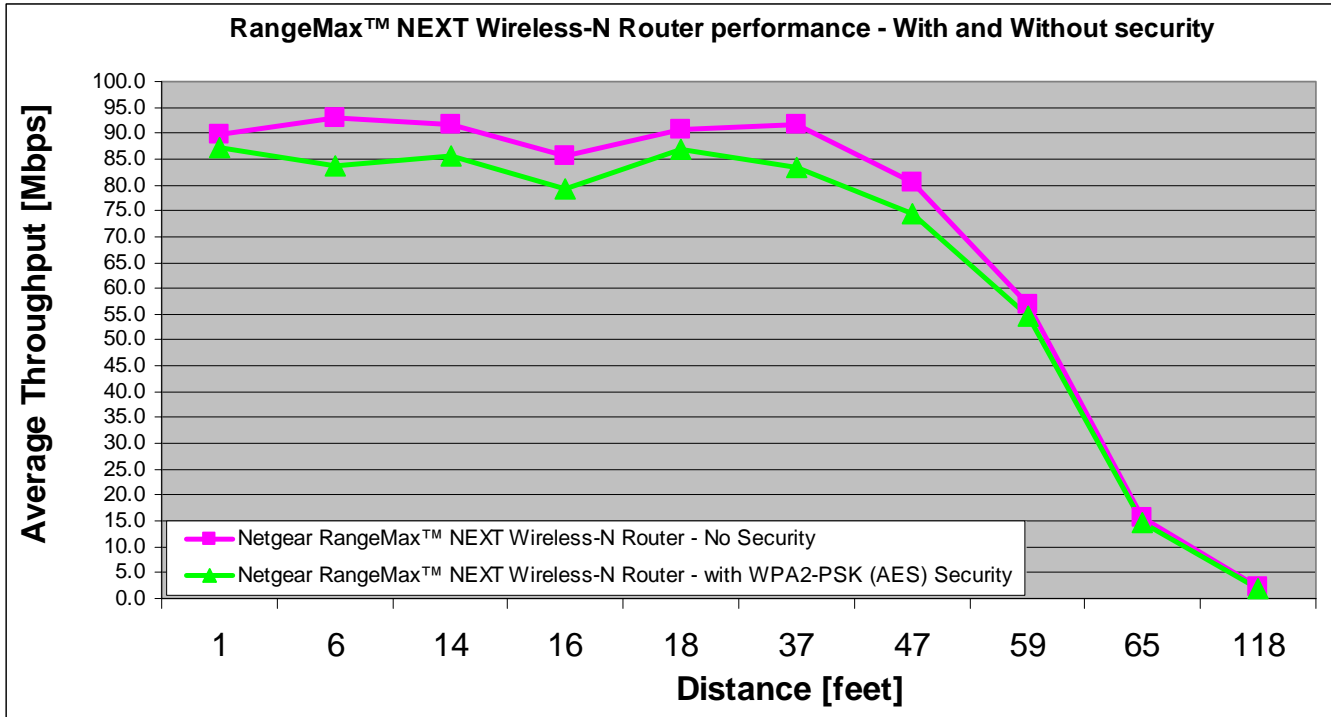
### Key Findings:

- NETGEAR RangeMax NEXT Wireless-N router performs the best at long range compared to competition.
- At 100+ ft distance, RangeMax NEXT Wireless N router provides throughput of 30 Mbps while other competitor routers throughputs goes down to less than 3 MBps.

### Figure 10: Configurations:

- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T).
- Linksys: Wireless-N Broadband Router (WRT300N) with Linksys Wireless-N Notebook Adapter (WPC300N).
- Belkin: N1 Wireless Router (F5D8231-4) with N1 Wireless Notebook Card (F5D8011).
- D-Link: RangeBooster N™ 650 Router (DIR-635) with D-Link RangeBooster N™ 650 Notebook Adapter (DWA-645)

**Wireless-N Throughput With and Without Security:**



**Figure 9: Wireless-N With and Without security –Throughput**

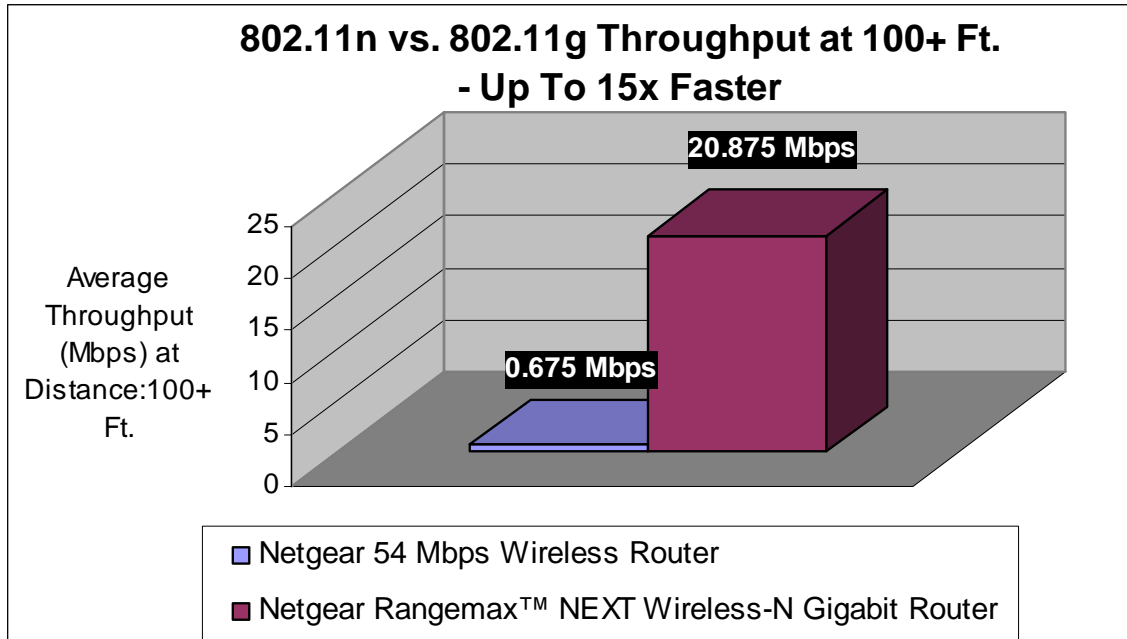
**Key Findings:**

- Minimum performance impact with AES 128-bit security enabled.

**Figure 11: Configurations:**

- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N Notebook Adapter (WN511B) - Without Security enabled.
- NETGEAR: RangeMax™ NEXT Wireless-N Router (WNR834B) with RangeMax™ NEXT Wireless-N Notebook Adapter (WN511B) -With WPA2-PSK (AES) Security enabled.

**Wireless N versus Wireless G Throughput at long distance**



**Figure 12: Wireless N vs. Wireless G Throughput at long distance**

**Key Findings:**

- ❑ Wireless-N router is up to 15x faster in performance compared to G Router.
- ❑ Performance is best at long distances where throughput really matters.

## Wireless N versus Wireless G Range

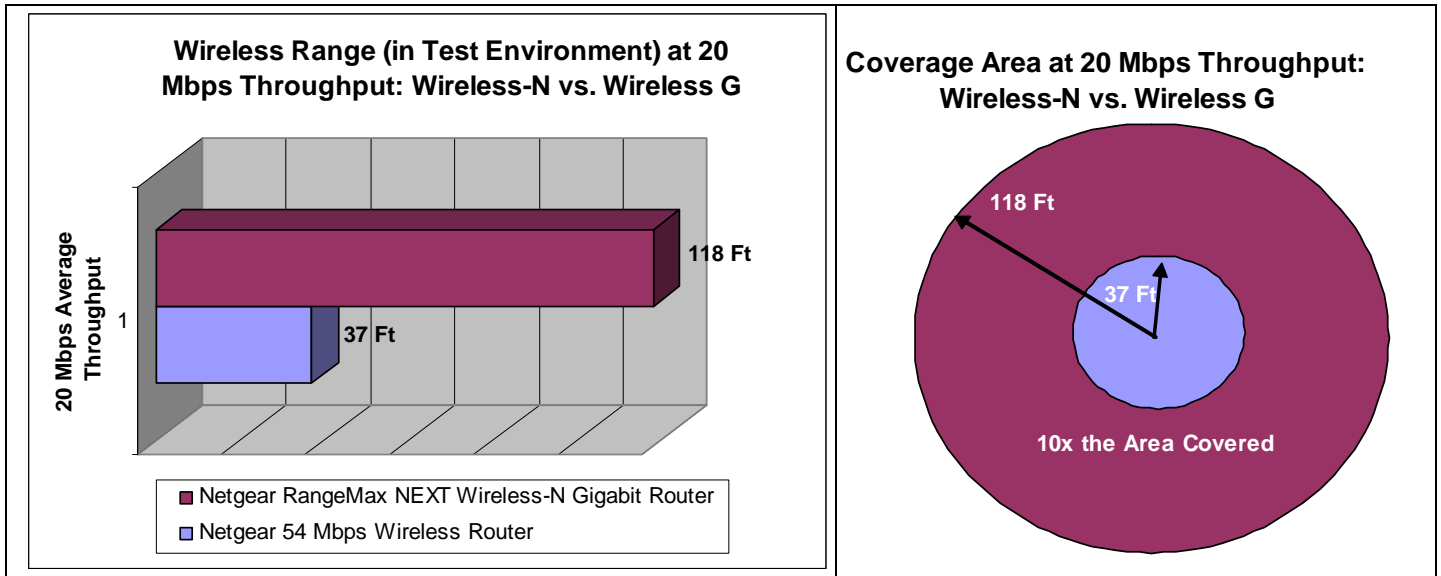


Figure 13: Wireless N vs. Wireless G Range

### Key Findings:

- ❑ RangeMax™ NEXT Wireless-N Router provides over 10 times the coverage maintaining 20Mbps average throughput compared to Wireless-G Router.
- ❑ RangeMax™ NEXT Wireless-N Router has enough bandwidth to stream HD video even at long distances” when used with RangeMax™ NEXT adapter.

### Figure 12-13: Configurations:

- ❑ NETGEAR: 54 Mbps Wireless Router (WGR614) with NETGEAR 54 Mbps Wireless PC Card 32-bit Card Bus (WG511)
- ❑ NETGEAR: RangeMax™ NEXT Wireless-N Router Gigabit Edition (WNR854T) with RangeMax™ NEXT Wireless-N USB 2.0 Adapter (WN121T)

Note: For specific Data reference, see the file, "Competitive Analysis Results.xls"



## Appendix A: System Configurations

Stationary Laptop (Location 1) Connected via Ethernet to the Router	
Laptop Manufacturer/Model #	IBM T42
System Ram/Processor	Pentium R 1.7Ghz, 1.7GHz, 1GB RAM
OEM OS	Window XP Pro. v2002 SP2

Mobile Laptop Connected via Wireless to the Router	
Laptop Manufacturer/Model #	IBM T42
System Ram/Processor	Pentium R 1.7Ghz, 1.7GHz, 1GB RAM
OEM OS	Window XP Pro. v2002 SP2

Secondary Laptop (Location 1) Connected via Ethernet to the Router	
Laptop Manufacturer/Model #	Fixed Fujitsu C series Lifebook
System Ram/Processor	Mobile Pentium R 2GHz, 1.9Ghz, 224MB RAM
OEM OS	XP Pro. SP2, v 2002

All references, in part or in full, to test results presented in this report must directly reference or link to this complete report. All references should be made to this report which will be posted in the competitive analysis test section of the Lionbridge web site.

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