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Economic Analysis of Kentucky Being a Part of the National Lambda Rail

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Executive Summary

Electronic connectivity and information network systems form a major part of the overall modern research infrastructure. High capacity networks allow for the sharing vast amounts of data between research laboratories, analysis of complex images, and other demanding computer applications. The major electronic information network that is being established in the USA to improve electronic communication in the research field is the National Lambda Rail (NLR). NLR is a nationwide broad bandwidth computing network used by leading research institutions. NLR provides national scale infrastructure for research and experimentation. Most of the member states of NLR have high ranking in terms of federal obligation to research and development. Among the south eastern IDeA states (states that have generally received a meager share of federal research and development funds) only Louisiana and Arkansas are a part of NLR.

<u>Kentucky and NLR</u>

As of now, Kentucky has not appropriated any funds to be a part of the NLR. Investing in NLR will require an upfront investment from the state and a million dollar per year commitment. The potential benefits will be realized only 3-5 years after investing in infrastructure because research labs can be set up that can utilize NLR's high broad bandwidth capacity. On the other hand, investing in NLR right now might make Kentucky more competitive for federal funds currently allocated to research. This study explores the benefits and costs/constraints involved in the decision of implementing NLR in KY. The study attempts to assign dollar values to the cost and benefits of this decision and evaluates if it's economically feasible for Kentucky's public institutions to be a part of NLR.

Economic feasibility

Net present values were used to calculate the amount of benefits (federal grant money) that would have to be realized in order to offset the costs. For the purpose of this analysis the infrastructure and user costs of connecting Kentucky to Washington DC were used. Sensitivity analysis was performed at various discount rates, growth rates and various life spans of NLR. The benefit amount needed to break even is sensitive to the life span of the project. Higher benefit amounts are needed to break even at lower life spans. The benefit amount is relatively the same with minor changes in discount rate and benefit growth rate. At a discount rate of 5%, the average benefits that have to be realized in order to offset the costs were approximately $1.8 million (assuming that NLR's lifespan is 20 years). The results of this analysis indicate that the benefit amount needed to break even with the cost of implementing NLR's minimum capacity can be realized by the two major research institutions in the state in the form of grant dollars. However for these institutions to get these grants, the state should provide financial aid and support. In addition, the state institutions could also consider joining Light rail consortiums headed by states like Georgia to further reduce the recurring costs.

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Introduction

Some of the South Eastern states have generally received a meager share of federal research and development funds (National State Technology & Science Index, 2004), which leads to these states identification as IDeA states (Institutional Development Award). One of the main contributing factors for the meager share of federal funding is a lack of investment in computing network infrastructure in the region. Existing computing networks in these states do not have the capacity necessary for computer interconnections that modern universities require for cutting edge research. High capacity networks are used in many fields of science like remote instrumentation, energy physics, material science, bioinformatics, pharmaceuticals and neuroscience imaging (Research Computing Task Forces Report, 2004). High capacity networks allow for the sharing of vast amounts of data between research laboratories for the analysis of complex images, and other demanding computer applications. Hence, in an effort to become more competitive for federal grants, many states are considering investing in statewide and interstate high band width networks like the National Lambda Rail (NLR).

NLR is a private fiber network consisting of more than 11,500 miles of coast-to coast dark (idle) optical fibers (www.nlr.net). The rail runs along both US coasts and through the central and southern parts of the country. ***NLR is the sole US research infrastructure owned by the research community itself.*** Members of NLR are universities and research organizations that have purchased the dark cables. NLR is capable of transmitting 32 or 40 simultaneous light wavelengths ('lambdas' or 'waves'). In contrast to Internet speed (~4 gigabits/second), each of these wavelengths is capable of transmitting 10 gigabits per second (www.nlr.net). Half of NLR's capacity is reserved for engineers to develop new networking technologies that will be more responsive to researcher needs (Daviss, 2005). The other half of NLR's capacity is used to create, find, store, share and analyze data. Scientists are connected to the NLR through a fiber-optic link from their institutions to one of the 27 hubs around the country (Daviss, 2005).

Long term federal investment will be based on the information technology provided by NLR. States that have a higher ranking in terms of federal R&D funding are members of NLR. The first connection of NLR was established Nov'2003 between Illinois and Pennsylvania (www.nlr.net). By the end of 2004, nine states were a part of NLR- Washington DC, Georgia, Illinois, Pennsylvania, Washington, North Carolina, Florida, California and Texas. Figure 1 shows the NLR connection along the US coasts. An increasing amount of funding is allocated to collaborative groups spread among different institutions. So in the absence of NLR, high speed access to researchers in other institutions and collaborative facilities such as Alliance Grid Cluster will be prohibitive (Research Computing Task Forces Report, 2004). Hence it is critical that research institutions are connected to NLR.

Figure 1: The figure below illustrates the current NLR member states. It also illustrates the existing NLR footprint (www.nlr.net).

Being a part of NLR requires an upfront investment that covers infrastructure costs. Member states have committed over $100 million to establish infrastructure (www.nlr.net). This huge infrastructure cost is one of the main constraints that prevent other states from investing in NLR. Among the south eastern states, only Louisiana and Arkansas have currently appropriated funds to be a part of NLR. States have used funds from various sources to invest in NLR. For example, Louisiana has used the proceeds from the tobacco litigation. While in some states, like Georgia, a combination of resources from state universities (Georgia Tech) and from government higher education funds have been used to meet the costs (Report on the State by State Progress of the eCorridors Project, 2005). The direct benefit is the potential for increased federal funding to research labs that utilize NLR. So the presence of labs specializing in high-tech computing and networking research is crucial in maximizing the benefits of NLR. In addition to the infrastructure cost, researchers have to pay user cost for NLR's services. Currently, most of the user cost is covered by grants awarded to research labs that utilize NLR. In the absence of high-tech labs that can utilize NLR's high broad bandwidth capacity NLR might be considered a very risky investment. This might be one of the reasons for hesitancy in some states to commit to NLR.

<u>Kentucky and NLR</u>

Relative to other states, Kentucky ranks at the bottom of National State Technology & Science Index in 2004 and ranks 44th in proportion of high-tech business (www.nsf.org). The Kentucky Information Highway and Kentucky Postsecondary Education Networks (KPEN) are the main information networks by which colleges and universities are connected (Report on the State by State Progress of the eCorridors Project, 2005). The KPEN network was implemented in spring 2004 and the state's public universities and the Kentucky Community and Technical College system are a part of KPEN. In addition to KPEN, the state of Kentucky is about to award a contract for a statewide network to support all state offices. This includes governmental offices, state libraries and the K-12 school system (Report on the State by State Progress of the eCorridors Project, 2005). Currently, University of Kentucky (UK) is independently planning to collaborate with the Oak Ridge National Laboratory by Fiscal Year 2007 (Research Computing Task Forces Report, 2004). The Oak Ridge connection allows UK to install fiber running between Lexington and Louisville. This connection will permit UK to receive a part of the NLR connection that is being installed between Atlanta and Chicago which passes through Kentucky (Report on the State by State Progress of the eCorridors Project, 2005). It is important to note the Oak Ridge connection is not funded directly by the state of Kentucky. The Oak Ridge connection allows UK to collaborate only with the Oak Ridge National Laboratory. It does not allow collaboration with researchers in other states.

In spite of the presence of these networks, Kentucky has not significantly invested in networking infrastructure. Multi-institutional partnerships among states might be difficult due to the absence of high capacity networks. This lack of connectivity with other states might result in foregoing funding opportunities due to technical inability to participate.

As of now, Kentucky has not appropriated any funds to be a part of the NLR (Report on the State by State Progress of the eCorridors Project, 2005). The costs incurred and benefit streams of investing in NLR are illustrated in Figure 2. State investment in NLR will require upfront costs and a million dollar per year commitment. The benefits will be realized only 3-5 years after investing in infrastructure because research labs should be set up that can utilize NLR's high broad bandwidth capacity. But investing in NLR right now might make Kentucky more competitive for federal funds currently allocated for research. Researchers from the higher learning and research institutions in the state will benefit and will be on par with other institutions in terms of technology. Besides, information and networking technologies are constantly being updated. So, the further behind Kentucky is in technology, the more it has to invest in the future to remain competitive with other states.

Figure 2: Benefits and constraints of Kentucky being a part of NLR

Benefits

- High broadband width capacity available to researchers
- Possible increase in federal grant funding
- Able to participate in more collaborative ventures
- Shows increase commitment by the state in improving infrastructure and this might lead to attracting more high tech business
- Increased commitment might have political implications like more support for the e-health initiatives

Constraints & Costs

- High non-recurring cost
- Absence of labs that are going to utilize the high capacity offered by NLR
- Benefits realized only after 3-5 years of investment
- High user cost

Generally the feasibility of a project is analyzed by weighing the benefits and costs. The direct benefit of NLR is an increase in federal funding. But it's very hard to identify the percentage of increase in federal funding that is due to the presence of high bandwidth capacity. Additionally, most states have implemented NLR in the last year and it's too early to observe the increase in funding. The indirect benefits of NLR are attracting high tech business and allowing for the implementation of other connectivity policies like e-health, by showing the state's commitment in improving technology. Though the causal link between connectivity and economic growth exists, it is hard to establish and quantify. In a study done by Cohen in North Carolina, investing in broad bandwidth infrastructure in a timely fashion with a sufficient information technology workforce is projected to result in substantial gains to the state economy (Cohen R, 2003). However, the study looked at gains to the private market which is more quantifiable than the gains to the public sector. Given these limitations in quantifying the benefits and establishing the causal direction of the relationship, the benefit cost ratio method cannot be used to analyze the feasibility of implementing NLR.

This study will try to analyze the feasibility of implementing NLR by using Net present values (NPV). NPV will be used to calculate the amount of grant money (discounted benefits) that has to be realized in order to offset the costs. This study will also analyze whether this amount can be easily achieved given the current infrastructure in Kentucky.

Research Question:

What is the benefit stream that has to be realized in order to offset the costs of implementing NLR in Kentucky?

Methods

To calculate the benefit streams that will offset the costs, the net present value (NPV) method is used in this study. NPV discounts the future benefits and costs at an appropriate discount rate and subtracts the sum total of discounted cost from the sum total of discounted benefits. Projects with a positive NPV indicate that the discounted benefits outweigh the discounted costs and the project should be undertaken. Projects with a negative NPV indicate that the discounted costs outweigh the discounted benefits and the project should be avoided. When NPV is equal to zero then the sum total of discounted benefits is equal to the sum total of discounted costs (i.e. the project breaks even). Since we want to calculate the benefits that offset the cost, NPV is set at zero in this study. The general formula for calculating NPV in this study is

$$\mathbf{NPV = 0 = -C + B_1\text{-}M_1/\ (1+r)^1 + B_2\text{-}M_2/\ (1+r)^2 + \ldots + B_t\text{-}M_t/\ (1+r)^t}$$

Where,

C = Infrastructure/capital cost,

B = Benefits,

M = Recurring/Maintenance cost,

r = discount rate,

t = lifespan of the project

Discount rate (r):

It is the interest rate used in calculating the present value of expected yearly benefits and costs and discounting reflects the time value of money (www.white house.gov/omb). The discount rate used for the analysis is <u>5%</u>. Sensitivity analysis is done by varying the discount rate to <u>4% and 6%</u>.

Number of years (t):

The number of years used in this analysis is <u>20 years</u>. Due to the high turnover in technology, sensitivity analysis is done by varying the life project at <u>10 and 15 years</u> respectively.

Growth rate (g):

To be conservative, the benefits are assumed to grow <u>2%</u> each year. Sensitivity analysis is done by varying the growth rate of the benefits from <u>0-2%</u>.

Costs:

The overall costs can be broadly categorized into non-recurring/capital costs (C) and recurring/user costs (M). The capital costs include laying out the fiber needed to connect universities within the state and NLR nodes in other states. The non-recurring cost includes the maintenance cost of fibers and equipment, user costs of utilizing the connection and the membership fees to be a part of NLR. Presently, the membership fee is one million dollars per year for 5 years. It is assumed in this study that the membership fee is constant and persistent over time. Both the capital and user vary according to the distance and the capacity. The cost of setting up NLR access that can provide 10 giga bit (the minimum capacity) connection to Washington DC along the established NLR foot print is used for this analysis. It is also assumed that Kentucky utilizes most of the existing NLR links that connect the other states. The costs of establishing new links to other states are higher and less practical. It should be noted that the costs of Kentucky establishing NLR links to other states and areas are going to vary. Table 1 shows the capital and maintenance costs of establishing 10 giga bit of NLR connection that links UK and University of Louisville (U of L) in Kentucky with universities/research organizations in Georgia, Tennessee and Washington DC (Report on the State by State Progress of the eCorridors Project, 2005 and Mr. Brian Savory, Office of Information and Technology, Georgia Tech-Personal Communication).

Table 1: Capital and Recurring cost of establishing NLR access from KY to DC

Establishing connection from UK to Louisville	**Capital cost**	**Recurring Cost/year**
Fiber from UK to U of L	$1,600,000	
Equipment for fiber	$400,000	
Annual Maintenance		$36,000
Oak Ridge Cost		
Equipment for 10 GB	$700,000	
Maintenance		$70,000

Table 1: Capital and Recurring cost of establishing NLR access from KY to DC (contd.)		
Establishing links in Georgia and Washington DC		
56 Marietta to 345 Courtland (NLR POP)	$60,000	$12,620
345 Courtland to NLR POP in Washington DC	$175,755	$21,216
NLR POP to Final Destination in DC*	$60,000	$12,620
Membership fees to NLR		$1,000,000
Total	**$2,995,755**	**$1,152,456**

*The capital and recurring cost of fiber from NLR POP to Final Destination in DC is not known, the costs are assumed to be same as 56 Marietta to 345 Courtland. The costs are more likely to be less than the costs assumed in the study.

Results

At a discount rate of 5%, the average benefits that have to be realized to offset the costs are $1,825,267. At 4% and 6%, the average discounted benefits to break even should be $1,752,977 and $1,902,689 respectively. The below table shows the benefits that have to be realized to break even with the costs, at various discount rates and benefit growth rates.

Table 2: Discounted Benefits needed to break even at various discount and growth rates
(The average life span of the project is assumed to be 20 years)

Discount Rate	Benefit growth %	Benefits that have to be realized to offset the costs (NPV is approximately equal to zero)
4.0%	0.0%	$1,873,213
	1.0%	$1,751,078
	2.0%	$1,634,640
5.0%	0.0%	$1,946,770
	1.0%	$1,823,453
	2.0%	$1,705,579
6.0%	0.0%	$2,025,573
	1.0%	$1,900,957
	2.0%	$1,781,538

Sensitivity analysis was also performed by changing the lifespan of the project. If the lifespan of the project is assumed to be 15 years, the average benefit needed to break even has to increase 16% (at various discount and growth rates). If the lifespan of the project is 10 years, the average needed to break even has to increase by 55% (at various discount and growth rates). Therefore benefit needed to break even is sensitive to the life span of the project. Tables 3 and 4 show the benefit streams when NPV is equal to zero at various discount and growth rates and when t is equal to 15 and 10 years respectively.

Table 3: Discounted Benefits needed to break even at various discount and growth rates (The average life span of the project is assumed to be 15 years)		
Discount Rate	Benefit growth %	Benefits that have to be realized to offset the costs (NPV is approximately equal to zero)
4.0%	0.0%	$2,111,134
	1.0%	$2,015,511
	2.0%	$1,923,231
5.0%	0.0%	$2,188,834
	1.0%	$2,091,664
	2.0%	$1,997,771
6.0%	0.0%	$2,271,229
	1.0%	$2,172,640
	2.0%	$2,076,822

Table 4: Discounted Benefits needed to break even at various discount and growth rates (The average life span of the project is assumed to be 10 years)		
Discount Rate	Benefit growth %	Benefits that have to be realized to offset the costs (NPV is approximately equal to zero)
4.0%	0.0%	$2,754,565
	1.0%	$2,689,558
	2.0%	$2,625,957
5.0%	0.0%	$2,848,498
	1.0%	$2,782,045
	2.0%	$2,717,003
6.0%	0.0%	$2,946,851
	1.0%	$2,878,892
	2.0%	$2,812,349

Conclusion

Investing in technologies like NLR not only improve research in public institutions but also are crucial for establishing projects like e-health initiatives that are needed for economic development in the state. This analysis uses a conservative approach and takes into account only the direct benefit (increased federal grant money for research) in looking at the feasibility of investing in NLR. The average benefit to break even 10 gigs of NLR is approximately $1.8 million (assuming the life span of NLR is 20years). The average benefit needed to break even remains the same with minor changes in discount rate and benefit. However, it should be noted that the benefit amount needed to break even is sensitive to the life span of the project. Currently the lifespan of NLR is not known; it's difficult to accurately estimate the lifespan of NLR's technology as connectivity technology is constantly evolving (Mr. Doyle Friskney, VP Associate Technical Services at UK, and Ms. Barbara Kucera, Director, Center of Computational Services at UK—Personal Communication). This should be taken into account when considering the implantation of this technology because higher benefit amounts are needed to break even at lower life spans.

Given the current infrastructure in Kentucky, the results of this analysis indicate that the benefit amount needed to break even can be realized. For example, the overall primary total awarded to various research departments in UK alone in the fiscal year 2005 was approximately $239 million. In the fiscal year 2005, the primary total projects awarded to the engineering research labs alone in UK were approximately $27 million (Sponsored Project Awards Reports, University of Kentucky). Additionally, the high bandwidth technology of NLR can be used in a various research areas like-bioinformatics, astrophysics. These figures show that researchers in the state are capable of getting federal grant funding that will cover the costs of NLR even when the lifespan of the technology is less than 20 years. However the state should provide start up financial aid and support for the institutions in Kentucky to get grant money needed for the investing in NLR. The state could aid in establishing the Oak Ridge Connection between UK and U of L. The Oak ridge connection is necessary for establishing NLR within the state. With the help of the state funds, it would expedite the project's implementation which in turn will make it easy to establish NLR access in the state.

To further reduce costs of implementing NLR, Kentucky can consider getting access to NLR by joining light rail consortiums like Southern Light Rail (SLR). SLR is a non-profit corporation providing NLR. SLR is led by Georgia Tech and provides NLR access to the Georgia Research Alliance universities and other universities in the Southern region of the United States (www.southernlightrail.org). By joining SLR, Kentucky gets NLR access at a lower cost. The capital costs for establishing the network remain the same. But the recurring costs are lower as the membership fee to SLR is only $200,000/year (NLR's membership fee is one million dollars/year). The average benefit to break even 10 gigs of high bandwidth connectivity from SLR is approximately $776,000 (assuming the life span is 20years). The benefit amount needed to break even is further lower and is economically more feasible to realize in terms of grants. However, the disadvantage of joining SLR is that Kentucky does not get to be a part of the NLR board. Policy makers should decide whether being a part of the NLR board is crucial to Kentucky's future initiatives.

It's difficult to quantify the benefits of a new technology and its impact in the economic development of the area. This analysis looks at the dollar amounts needed to make the investment worthwhile. This analysis does not take into consideration all possible variations in distances or capacity of NLR. It looks at a particular connection which provides the minimum capacity of NLR (10 gigs). Despite the exclusion of variations in distance and capacity, the results of the analysis do indicate that it is economically feasible for public institutions in Kentucky to establish NLR connectivity with neighboring states.

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