1.NREN REFERENCE MODEL
2.SDN DYNAMIC ROUTING ALGORITHM

UST Global Intern 2019

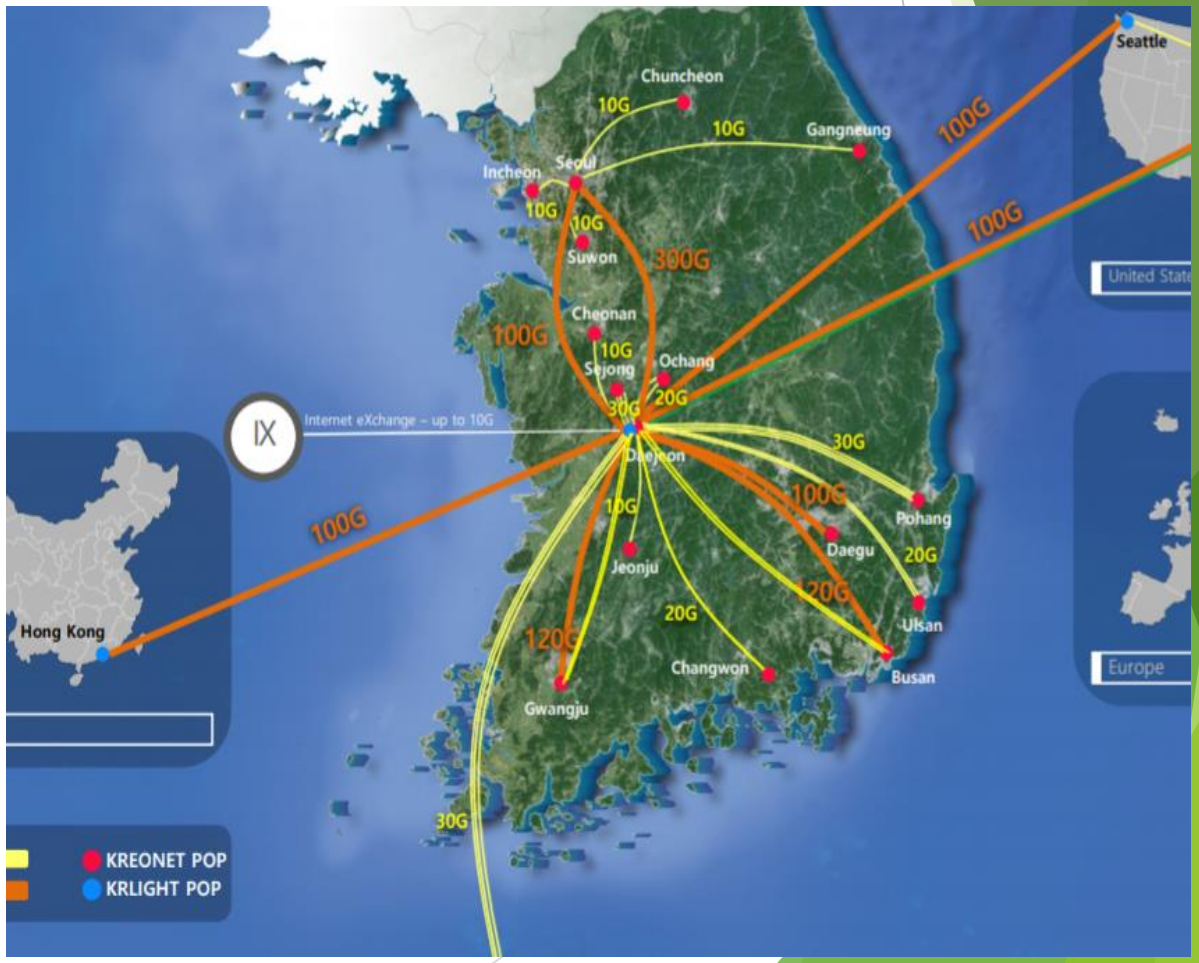
Contents

Introduction to NRENs

- Networks designed to serve the R&E community
- Significances of NRENs:
  - Dedicated to R&E community
  - Promote collaboration
  - Resource sharing
  - Fast, secure and reliable
- Examples of NRENs:
  - KREONET, CA*net, AAARNet, UNINET, ZAMNET, NORDUNet, Internet2 etc

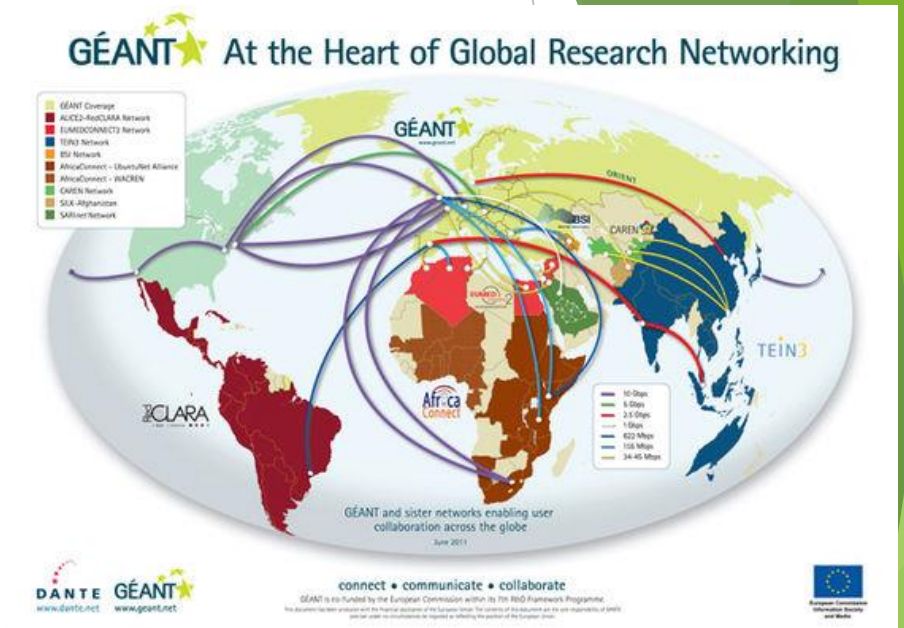
KREONET
Korea Research Environment Open Network

- Korea's National Science & Research Network since 1988.
- Up to 200Gbps Backbone between Seoul and Daejeon.
- Hybrid Network.
- Connects about 200 R&E organizations in Korea.
- Supports 1Gbps and 10Gbps User connections.
- 365*24 Network Operation Center Service.
- Supports Lightpath Provisioning and Dynamic Ethernet Service for Advanced Apps, IP Production Networks for General R&E Applications.



Global R&E Networks (Internet2 and GEANT)

- GEANT:
  - An R&E network connecting European NRENs.
  - Aims to connect as many R&E Networks as possible.
  - Extends to AfricaConnect2, Asi@Connect (TIEN*CC backed by the Korean Government) and Internet2 in the U.S.A.
  - Supports other non EU NRENs; eg AfricaConnect, Asia@Connect and ASREN.
- Internet2:
  - A network advanced to the Internet.
  - Aims to connect all U.S.A NRENs.
  - Provides more advanced services compared to the Internet.
  - Includes the military and other organizations.



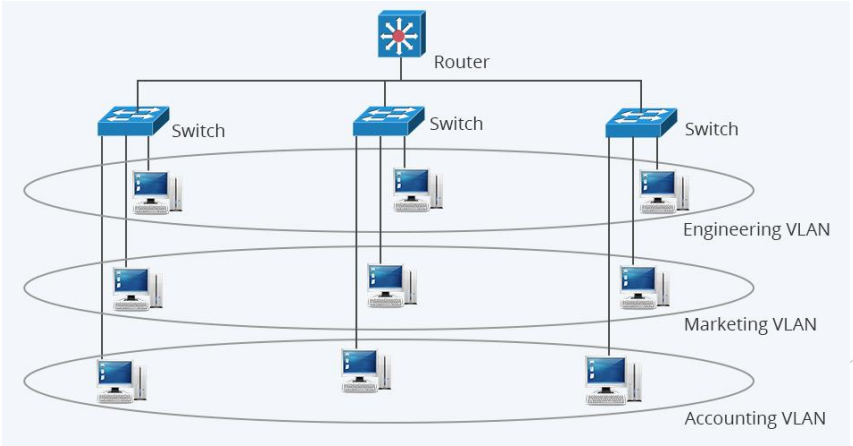
NREN Reference Model

- A reference model based on Advanced Networking Technologies.
- For countries in the early stages of NREN establishment and,
- Countries seeking improvement on their NREN.
- Issues covered:
  - Services Model: defines which services the NREN would provide to members
  - Governance Model: how the NREN government can be organized.
  - Funding Model: how funds for establishment or improvement can be raised.
  - Architectural and Infrastructural Models: Necessary infra and the proposed architectural model.
  - Inclusion of developing Countries.
  - A case study of developing countries RENs (RENU in Uganda).

NREN Reference Model
The services model.

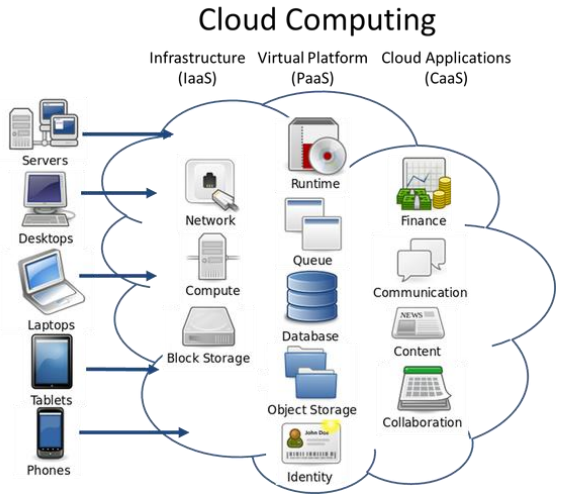
- Advanced Layer 1 services:
  - Wave Services
  - Dark Fiber Services
- Advanced Layer 2 services:
  - Dynamic and Static VLANs.
  - Interdomain Connectivity.
- Advanced Layer 3 services:
  - IP Network services.
  - Peer Exchange services.

Unleased fiber/Dark fiber



VLANs

NREN Reference Model
The services model.



Data center services

eduroam

NREN Reference Model
The Governance model.

NREN Directory Board

Corresponding Ministry

Member Institute Network Management

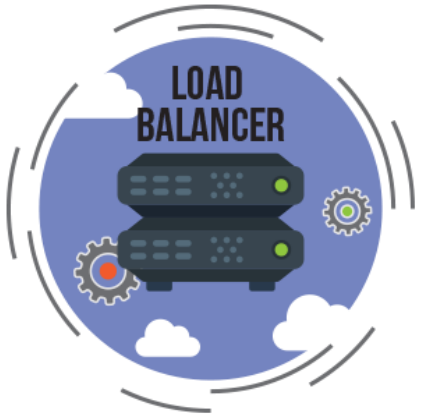
Physical Network Tech Board

International Activity Board

NREN Reference Model
The Funding/Financial model.

- Campus network establishment and maintenance:
  - Covered by the member institutes.
  - Government institutes acquire funds from the government.
  - Larger member institutes may pull up small institutes in partnerships.
- Backbone network and other coverages:
  - Establishment funds by agreed member institutes and the government.
  - An established joining fee for institutes that join later.
  - Institutes would pay a maintenance fee.
  - Expansion fees requiring huge funds would be supplemented by the government.

NREN Reference Model
The Infrastructural model.



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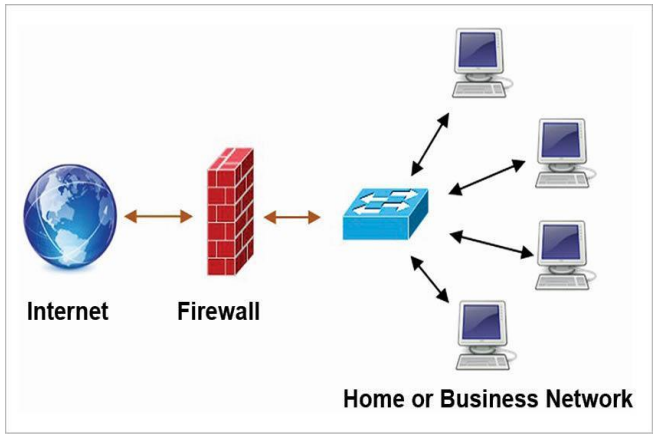
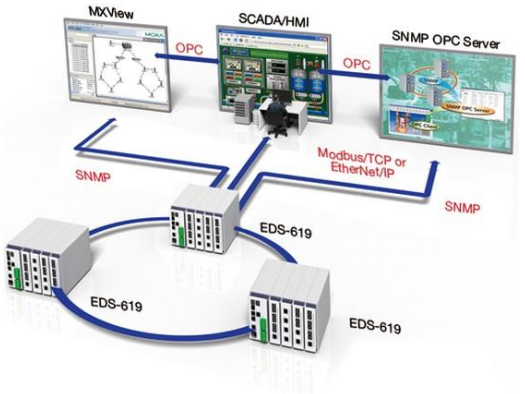
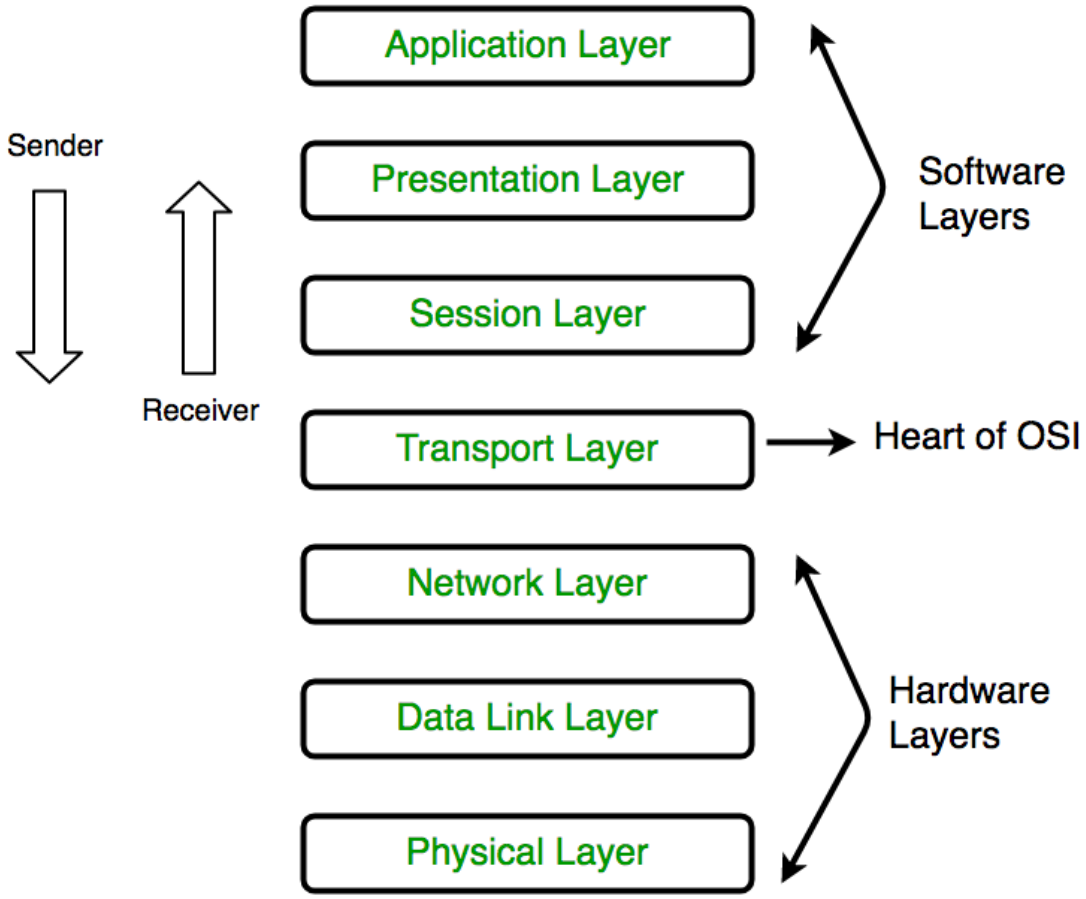
The Infrastructural model.





NREN Reference Model
The Architectural model.



NREN Reference Model
Adoption by developing countries

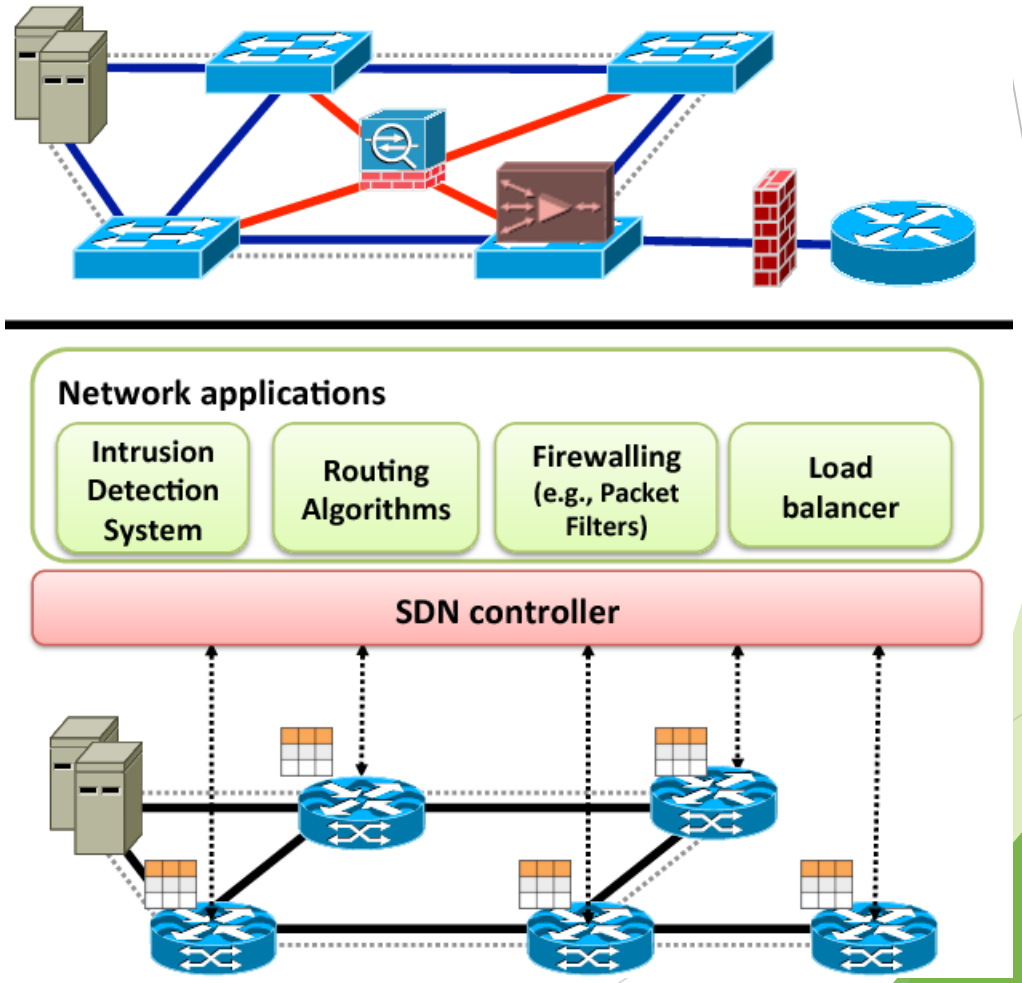
- Factors hindering NREN establishment in developing countries:
  - Limited Funding:
    - World bank funding solution
  - Technological backwardness:
    - Collaboration with developed countries and global R&E networks
  - Isolation from global R&E communities:
    - Efforts to participate in global research,
    - Efforts to collaborate with more powerful R&E communities.
    - Requests to connect to global RENs.

Conclusion

- Lessons:
  - The significance of R&E networks.
  - Advanced Networking Technology Research.
  - Challenges of R&E networks.
  - Efforts to counter the challenges.
- Future plans:
  - Publishing the reference model for public use.

Introduction to SDNs

- Separation of the data plane from the control plane
- Switches relieved
- Controller has whole picture of the network.
- Open switches are used.



Routing Algorithms

- Static routing algorithms:
  - Installed on switches or the controller.
  - Usually based on the shortest path.
  - Does not take into account the changing circumstances of the network.
- Dynamic routing algorithms:
  - Used in SDNs.
  - Incorporates shortest paths and the changing circumstances of the network.
  - Changes in delay, bandwidth etc. are considered.

Proposed Dynamic Algorithm

- Initialization of shortest path by distance and available bandwidth.
- Each packet from a switch signals the controller
- Controller calculates temporary shortest paths based on remaining bandwidth.
- Controller updates the forwarding tables of switches.
- Future packets are routed based on the forwarding table updates

Algorithm Performance in Comparison with Static Algorithms

Static Routing Algorithm	Developed Algorithm
• Increased delay due to packets routing to fixed outlays. • Packet drops even in cases of minimal delay and congestion. • Fixed routes resulting in similar routes for different packet sizes; poor utilization of available resources.	• Flexible routes countering minimal delay. • Minimal/No packet drops due to reduced congestion. • Packets routed according to available resources.

Conclusion

- Lessons:
  - Designed a simple network simulator using C++ programming.
  - Practiced multithreading.
  - Acquired a better understanding of packet flow through networks.
  - Acquired a better understanding of algorithm design and their mathematical evaluation.
  - Acquired a better understanding of layered networks and SDN routing.
- Future works:
  - Compare the developed algorithm with other dynamic routing algorithms.
  - Learn about the different routing measures on lower layers.