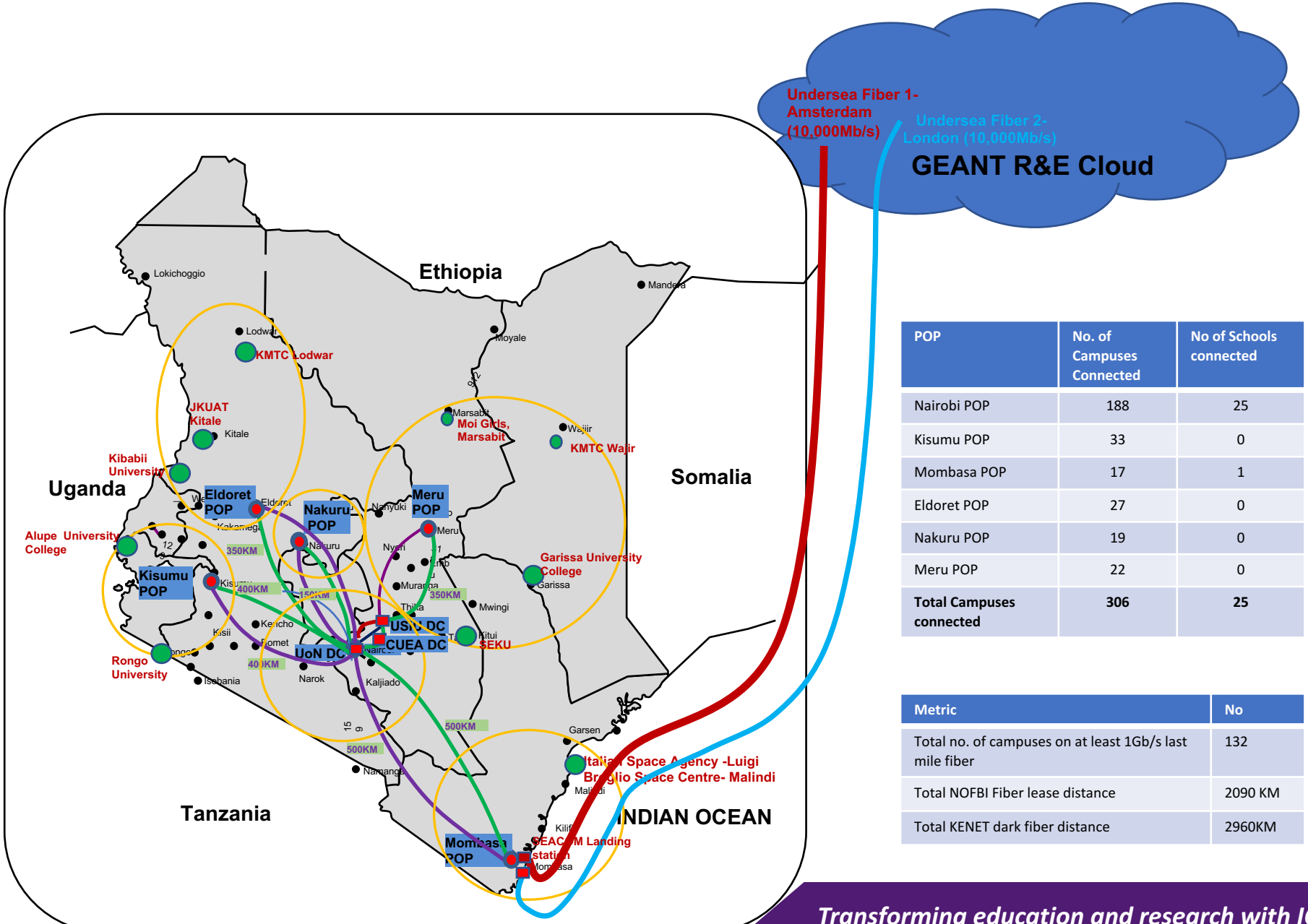
kenet
Kenya Education Network

Off-Campus Connectivity Through APNs

Today's Agenda

- Current KENET Broadband Network
- KENET's COVID-19 Response
- Discounted Data Bundles Solution
- Private APN
  - For Institutions
  - For End Users
  - Challenges Encountered
- Conclusions

KENET National Broadband Network Coverage – July 2020



POP	No. of Campuses Connected	No of Schools connected
Nairobi POP	188	25
Kisumu POP	33	0
Mombasa POP	17	1
Eldoret POP	27	0
Nakuru POP	19	0
Meru POP	22	0
Total Campuses connected	**306**	**25**

Metric	No
Total no. of campuses on at least 1Gb/s last mile fiber	132
Total NOFBI Fiber lease distance	2090 KM
Total KENET dark fiber distance	2960KM

KENET response to COVID-19

- Negotiation of discounted data bundles
  - Based on 500,000 university students' projection
  - ~USD 5 per 10 GB, normal is ~USD15 for 10GB
- Implemented KENET Private APN (3G/4G LTE)
  - Sponsored discounted bundles service for lecturers
  - 5,000 FREE sponsored 30GB monthly bundles for faculty and staff
- **Facilitated whitelisting of educational resources & mobile numbers**
  - URLs and Mobile numbers for discounted bundles

User Authentication on Discounted Bundles

- Whitelisted Users
  - Based on MSISDNs – mobile numbers
  - Uses existing APNs on MNO networks
  - Registration Portal - KENET Provided a registration for enrolment
  - Support Portal – for any user access challenges, backed up by home institution
- Whitelisted Resources
  - Only whitelisted resources accessible
  - IP Based whitelisted
  - Doesn’t work well for resources on dynamic IPs
  - Some resources need whitelisting of entire IP Prefixes/Blocks

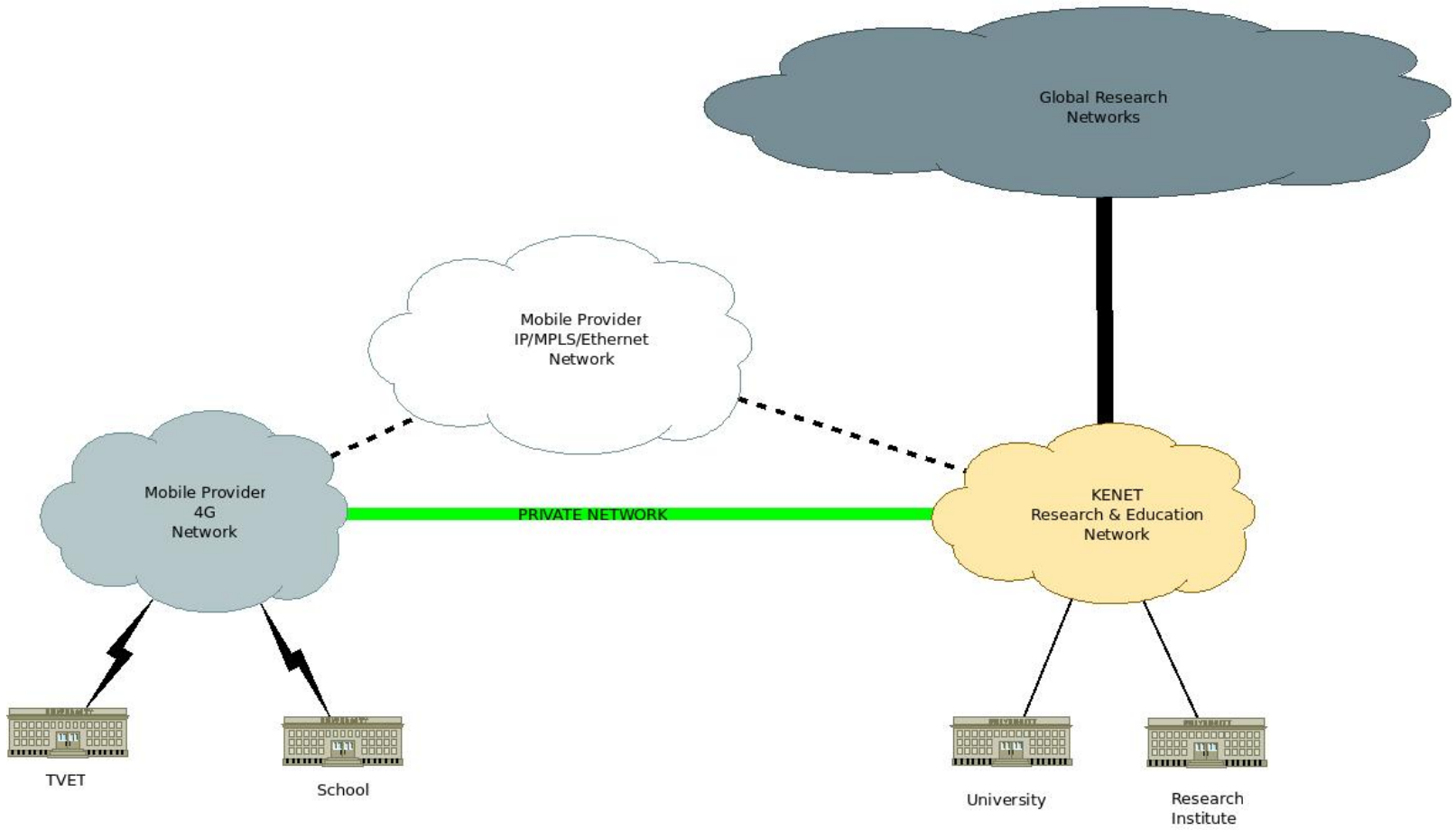
Private APN using MPLS over GSM

- Our Private APN Journey
  - First discussions in 2010 September (with Safaricom)
  - Initial idea to connect remote school in Marsabit on 3G
  - Solutions provided in 2010 not affordable – Data Bundles based
- 2017 Revival
  - Focused on connecting Schools & TVETs in Kenya
  - Idea to connect educational institutions with minimal budgets
  - Leverage on low installation costs to support small schools
- 2019 Traction
  - Agreed design to support schools and TVETs
  - Schools & TVET design based on dedicated capacity per institutions
  - Not bundles based
  - POC agreed for selected schools
- 2020 Implementation
  - COVID-19 disrupted POC for schools
  - KENET engaged on Private APN for end users
  - KENET implemented bundle-based APN for end users

2017 Ideas on TVET and Schools 4G Last Mile

- Private APN
  - Private APNs would enable KENET or KENET members to connect to the Kenyan Education Network simply and securely
  - Service provider to create a Private APN on the 4G network which is extended to KENET as a private network (VPN)
  - APN to be capped on capacity (say 5Mb/s or 10Mb/s) - not based on bundles
  - Connections are extended to KENET mimicking a lease line but with 4G last mile technology
  - Schools and TVETs will host a 4G router that joins the Private APN
  - Connection extended by the mobile network provider to KENET and handed over on Ethernet as a private network
  - Actual private network will traverse the mobile provider's 4G network as well as IP/MPLS/Ethernet backbone network then handed off to KENET as Ethernet Layer 2 service
- Anticipated Benefits
  - Device specific IP addressing - the end devices will be assigned KENET IP Addresses
  - Simple 4G-based network in place of microwave radio lease lines for low budget installations
  - Faster and easier deployment, operation and maintenance

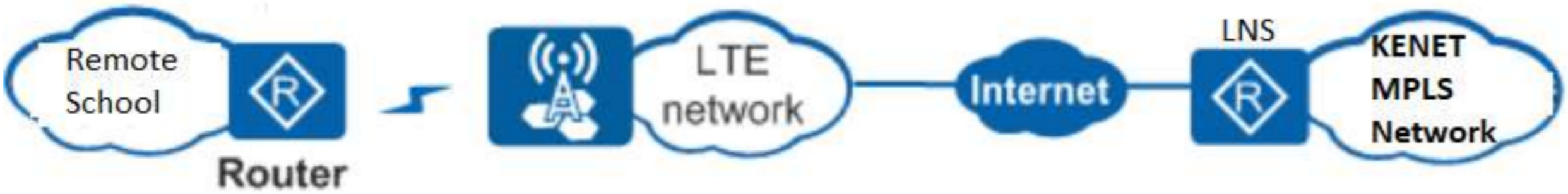
2017 KENET Private APN Design



Final Design of Private APN for Schools - 2019

- MNO Constraints on APN Solution
  - Only option Internet Bandwidth access on the 4G Dedicated Capacity product
  - Inability to propagate KENET Public IPs to end user
  - No default Gateway on Private APN
- Compromise Design
  - MNO to create a Private APN on their 4G network which is extended to KENET as a private network (VPN)
  - APN to be capped on capacity up to 7Mb/s (3Mb/s, 4Mb/s, 5Mb/s, 6Mb/s or 7Mb/s) - not based on bundles
  - The links to be delivered to KENET through MPLS on Private IP Addresses
  - School LANs to be assigned private IP Addresses that are then propagated to KENET using L3 MPLS VPN
  - KENET to NAT the school Private IP Addresses to public IP Addresses
  - MNO to provide 4G/LTE Access Router for each site with outdoor antenna
  - Access routers to be monitored on NMS

2019 Final Schools Private APN Design

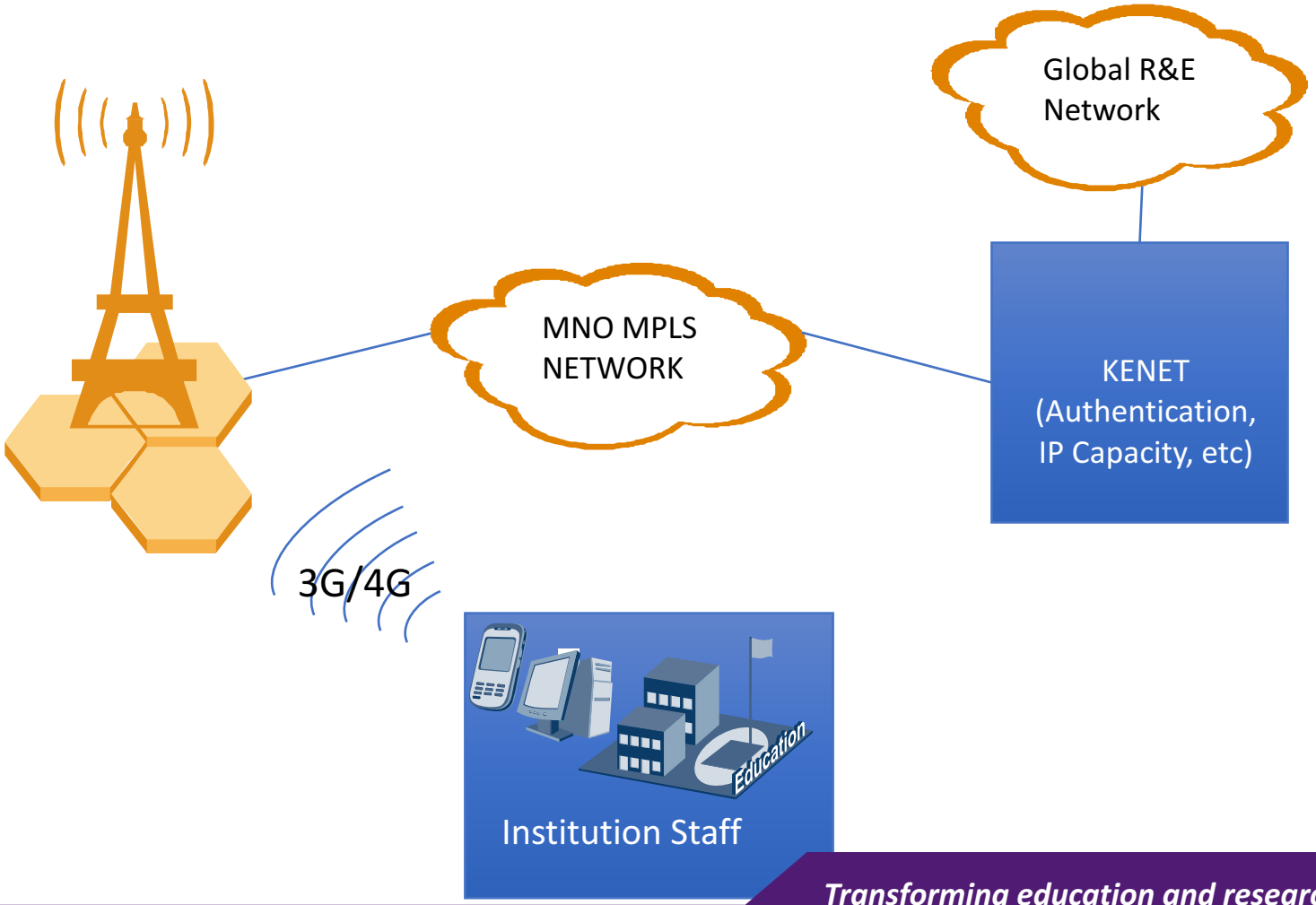


2019 Final Schools Private APN - CPE

Private APN for Off-Campus Access

- KENET Original Ideas
  - Provide access for staff and students distributed all over the country
  - Leverage on GSM for the last mile for the staff and students
  - Support faculty and researchers to continue working/teaching remotely during restricted movement period
  - KENET constrained on reaching end users dispersed all over country and not on campus
- Final Implemented Solution
  - MNO to provide 5,000 SIMs loaded with 30GB worth of monthly data
  - GSM service will be delivered on As-Is Basis, can only be used on where MNO GSM network is available
  - MNO to extend default gateway on the APN
  - SIM cards will be registered to KENET
  - KENET responsible for distributing the SIM cards and identification of users in case of fraud
  - Users MUST be authenticated/identified to access services over the Private APN
  - KENET responsible for security for the users and any content filtering if necessary

Off-Campus Private APN - Design



Support Infrastructure for Off-Campus Access

- User Registration Database & Support Portal
  - Roll out of Registration Portal - to capture user details and assign specific MSISDNs to specific users
  - Registration verification – required institution email
  - Support Page for FAQ and Issue tracking
  - Countrywide SIM Distribution logistics – per institution
- Identity Database for Users
  - To provide identity for users without institutional credentials
  - Based on LDAP
  - Ability to provide virtual LDAP – institutional virtual identity service
  - User Portal – for token reset (2FA)
  - Administration Portal – allows institutional administrators to administer their databases
- User Authentication
  - MNO required that KENET authenticates users
  - DHCP service not extended to KENET – done at the MNOs end with no relay
  - Only option was IP based or introduction of forwarding Proxy
  - IP-based Authentication Implemented – easiest at the time based on constraints

User Authentication on Off-Campus Private APN

- Proxy-Based Authentication
  - KENET wasn't ready with quick solution to provide forwarding proxy
  - Requirement was to only allow user with valid identity access to resources outside KENET
  - Leverage on existing identity databases - at the member institutions and only support a few users from institutions with no identity databases
- IP-Based Authentication
  - Used as the implementation
  - LDAP & radius-based
  - Leverages institutional identity databases
  - KENET's managed identity database - for institutions without identity databases
  - IP-based implementation not clean – DHCP leases change every 3 days and authentication aligned to age every 3 days
  - Still looking at alternative methods – e.g. proxy-based forwarding proxy

Challenges - Private APN for Off-Campus

- Inadequate 4G/LTE Coverage
  - Most areas with 3G coverage
  - Some areas without 4G/LTE coverage – or minimal coverage
  - MNO had to allow 3G devices to connect on the Private APN
- End User Devices
  - Most users have 3G modems
  - Ownership of 4G/LTE modems and devices limited
  - MNO had to allow 3G devices on the private APN
  - KENET encouraged end users to secure 4G/LTE modems/devices
- Requirement for Restricted Access
  - MNOs only interested in access to whitelisted/KENET hosted resources
  - Reluctance to provide default gateways on the private APNs

Potential Uses of Private APN

- Off-Campus Access
  - To support remote working and teaching
- Last Mile Connectivity
  - For small institutions with limited budgets
  - For remote locations to reduce installation costs
- Research Data Collection
  - For integration with IoT Devices
  - Data transmission for distributed sensors

Conclusions

- Constraints of Campus-based Network
  - *No reach when users move to remote areas during holidays or closures*
  - *High installation costs for schools and tertiary colleges in remote areas*
- Design Solution Based on Problem
  - *Solution for Institutional subscriber different from that of end users*
  - *Some cases may just need whitelisting or resources to use existing bundle solutions*
- Provide Support Mechanisms for Solution
  - *Tools and mechanisms to ensure solution meets design requirements*
  - *End user support to ensure solution meets user needs*
- Demonstrate Value to MNO
  - *May need multiple iterations to convince MNOs*
  - *Demonstrate value both to the common good and MNO*

Thank You

www.kenet.or.ke
Jomo Kenyatta Memorial
Library, University of Nairobi
P. O Box 30244-00100, Nairobi.
0732 150 500 / 0703 044 500