Dissolved Gas Analysis

The Health Indicator for Oil Immersed Transformers

By RAJARSHI GHOSH

7th April 2017

What is DGA

- It is the most effective tool for advanced detection of almost all types of incipient fault inside an oil filled transformer.
- In a live transformer, Gases in oil always result from the decomposition of electrical insulation materials (oil or paper), as a result of faults or chemical reaction in the equipment.
- Different gases are generated at different situations and a particular fault can be detected by analysing the fault gases dissolved in the oil.

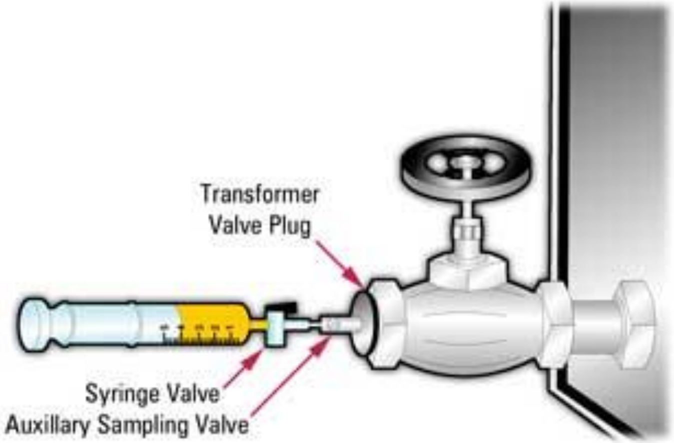
Why DGA is Essential

- The most reliable and proactive method for identification of fault inside a transformer at an early stage of development.
- Used world wide since 1960s.
- To reduce risk to the unit – Plant outage
- To reduce risk to the system it is connected - Interruptions / shutdown
- To reduce risk to the company – Loss of property / brand name
- To reduce risk to the personnel – Injury / Loss of human life (internal / external)

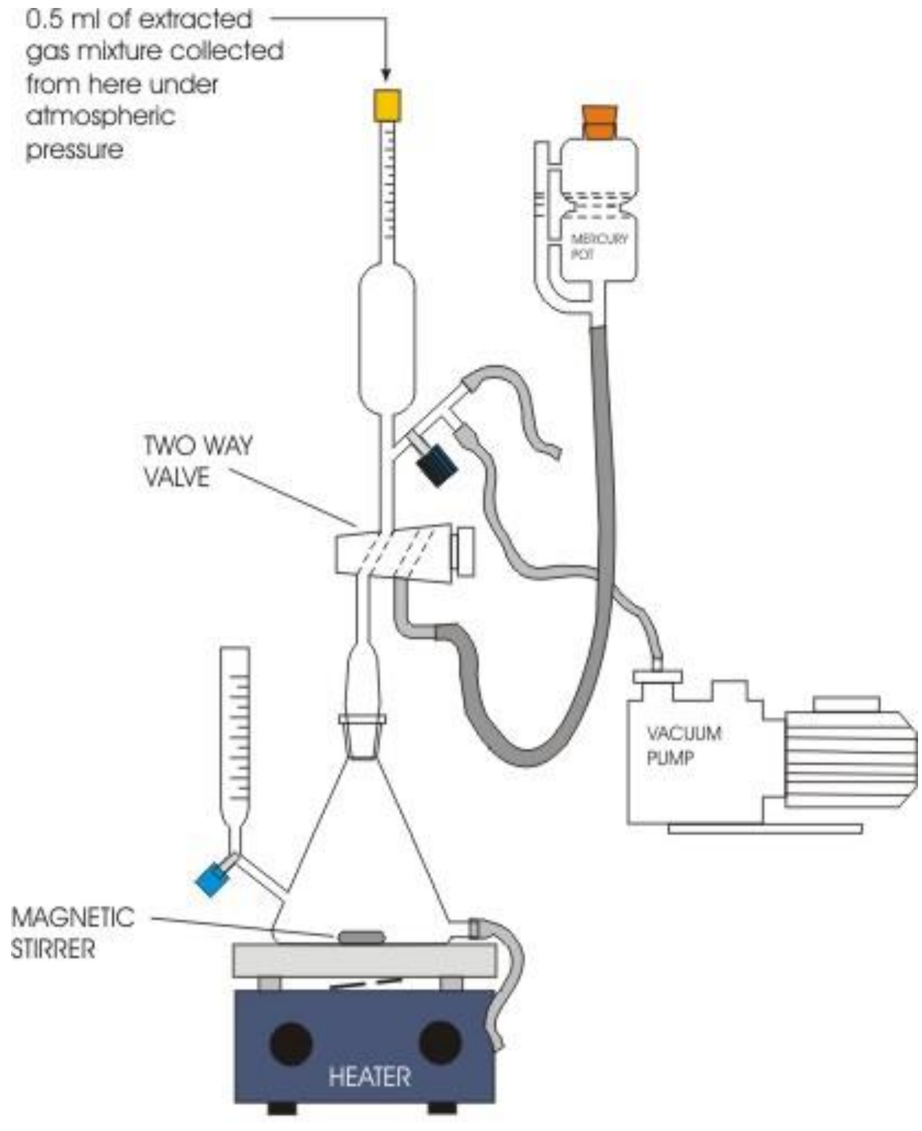
When to Conduct DGA

- In the factory –
  - After high voltage and temperature rise test
- At site –
  - After high voltage testing
  - Immediately before commissioning
  - Within two days after commissioning
  - After one month of commissioning
  - Before lapse of warranty period
  - After any major fault
  - **Periodic checking / online arrangement**
- At the end of life (Academic purpose)

Sampling Method

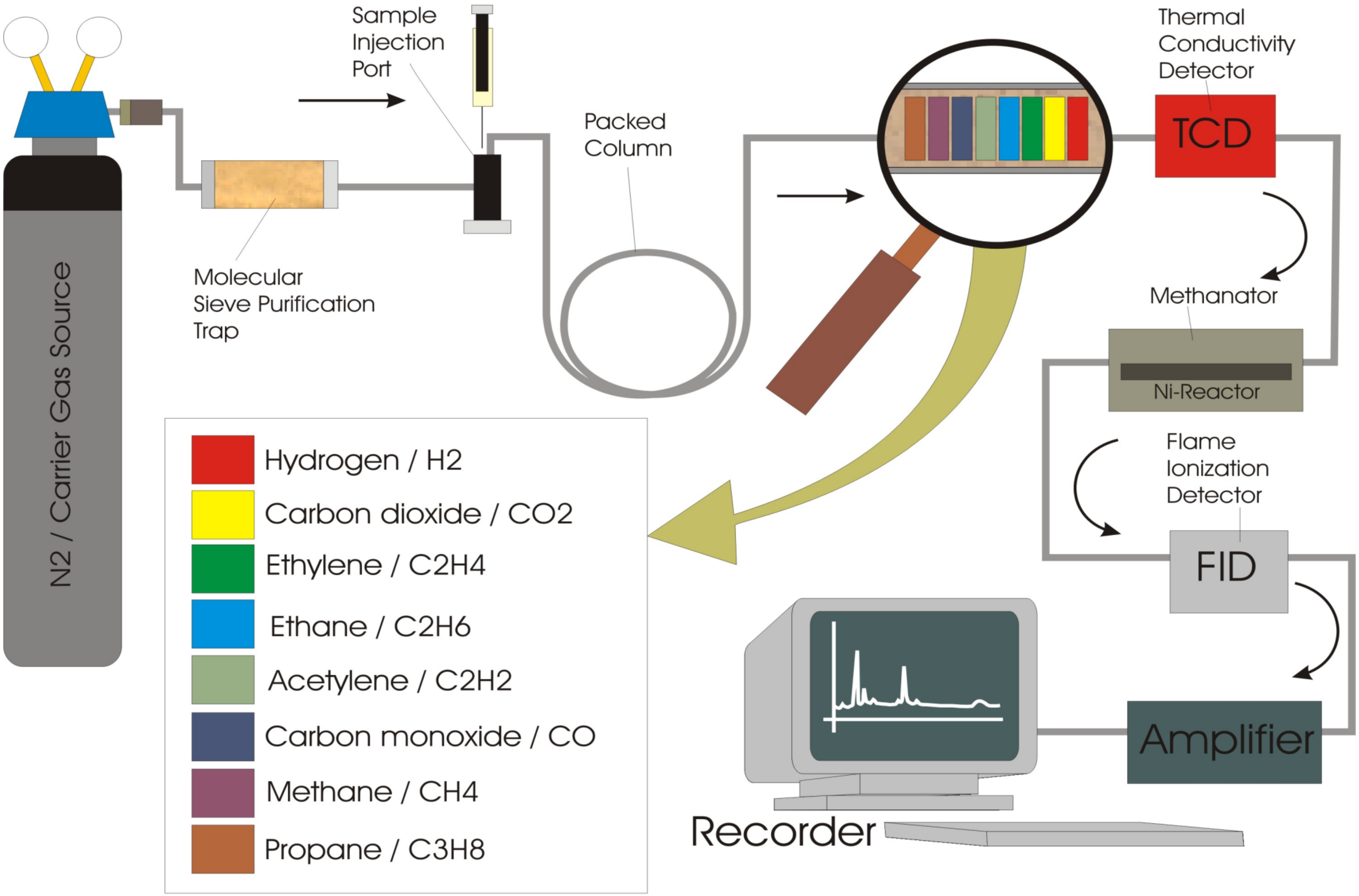


Gas Extraction



GAS EXTRACTION APPARATUS

DGA Process



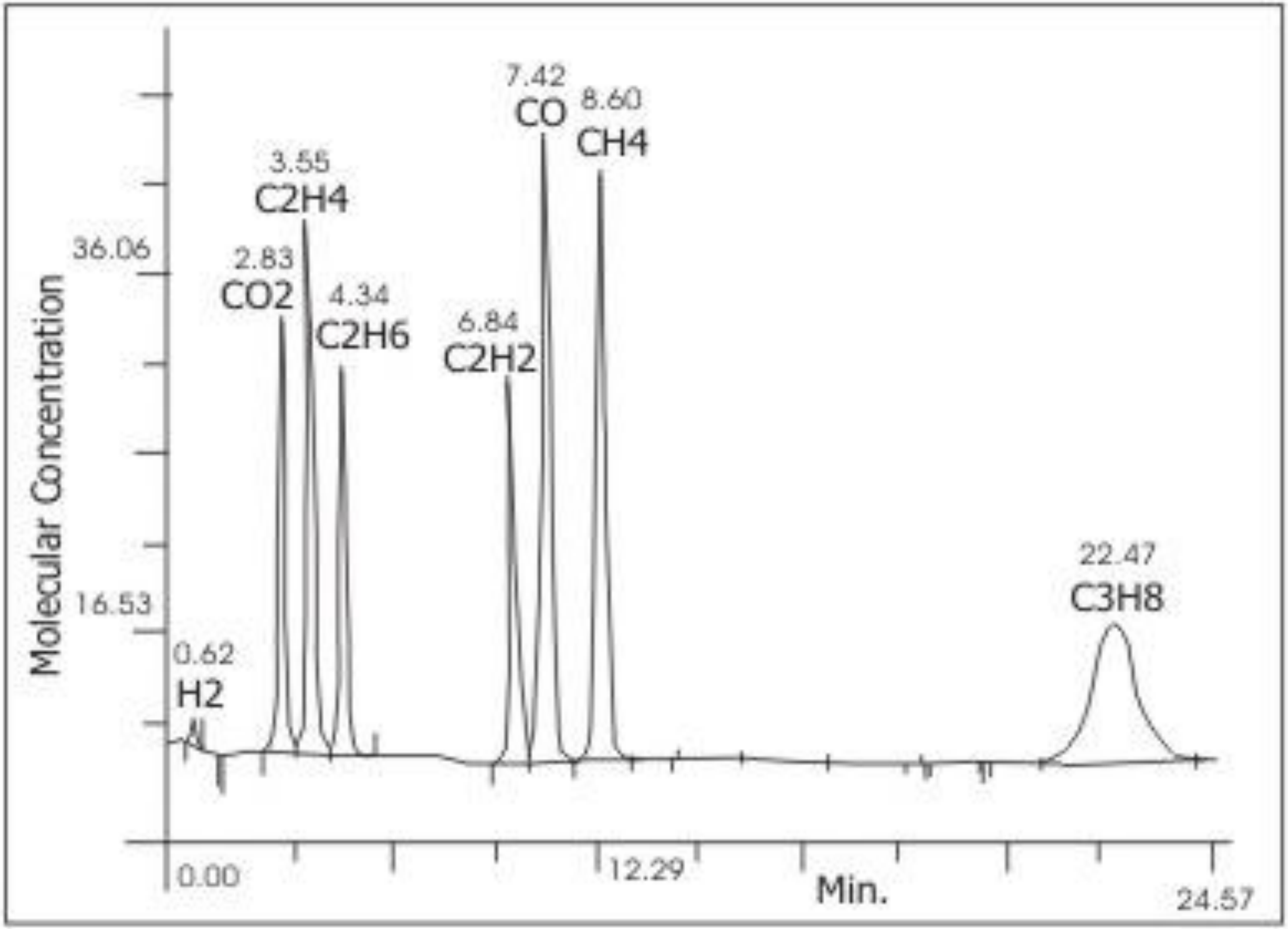
TYPICAL GAS CHROMATOGRAPHIC SYSTEM

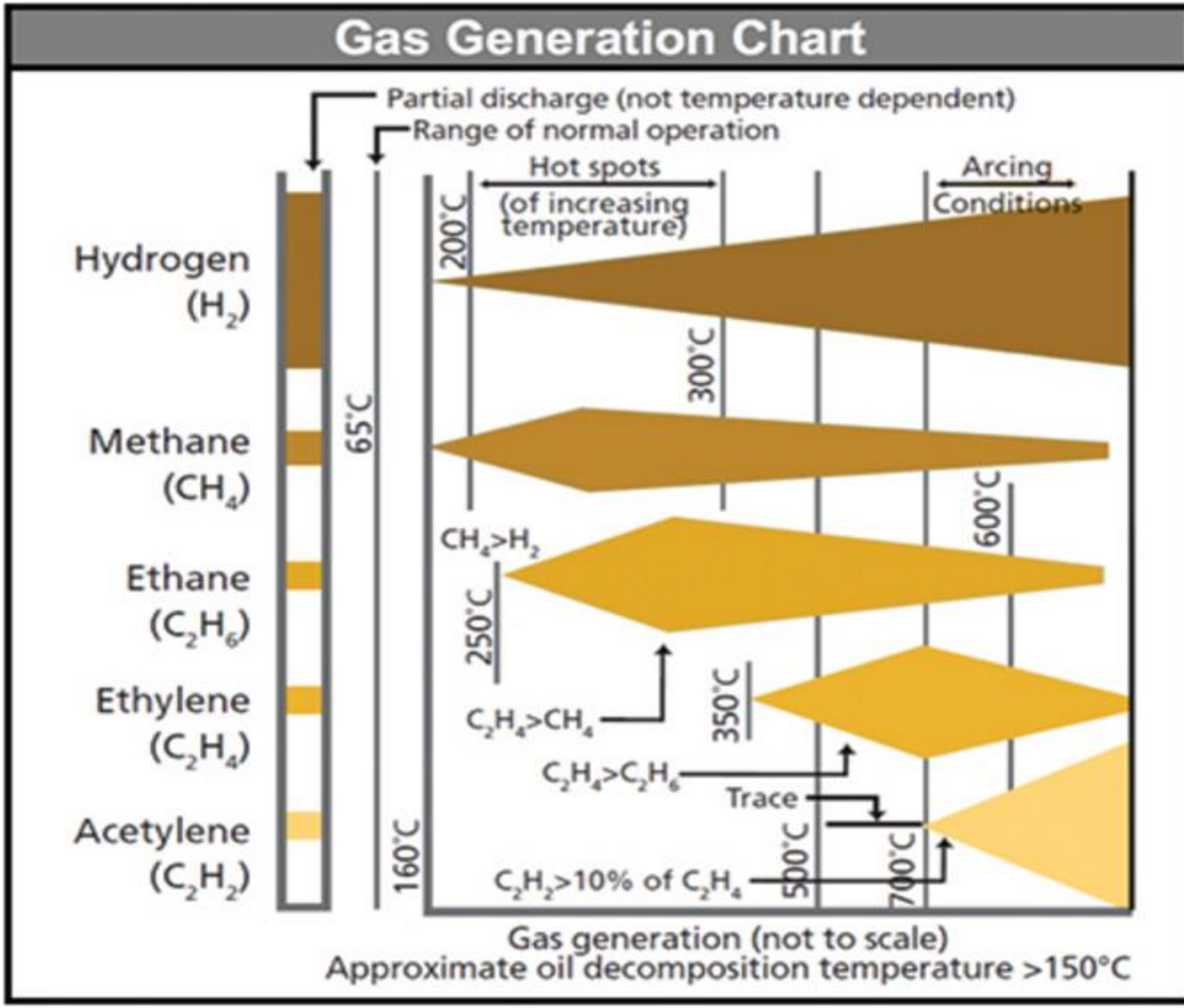
RP-Sanjiv Goenka Group
Growing Legacies

Gas Analyser

CESC LIMITED
Energising Lives • Since 1899

Chromatogram




Gas Generation Chart
Partial discharge (not temperature dependent)
Range of normal operation
Hot spots
(of increasing temperature)
Arcing
Conditions
Hydrogen
(H_2)
Methane
(CH_4)
Ethane
(C_2H_6)
Ethylene
(C_2H_4)
Acetylene
(C_2H_2)
65°C
160°C
200°C
250°C
300°C
350°C
500°C
600°C
700°C
CH_4>H_2
C_2H_4>CH_4
C_2H_4>C_2H_6
Trace
C_2H_2>10% of C_2H_4
Gas generation (not to scale)
Approximate oil decomposition temperature >150°C

Interpretation Techniques

Technique - 1 : Permissible concentration of gases in a healthy transformer

Actual concentrations of different gases for various ages of transformers vary very widely as a result of different operational methods and transformer designs. The normal concentrations (or norms) for healthy transformers of various ages are based on the rich experience of the leading utilities on the globe.

Gas (in ppm)	< 4 Years of service	4 to 10 Years of service	> 10 Years of service
Hydrogen (H_2)	100 - 150	200 - 300	200 - 300
Methane (CH_4)	50 - 70	100 - 150	200 - 300
Ethane (C_2H_6)	30 - 50	100 - 150	800 - 1000
Ethylene (C_2H_4)	100 - 150	150 - 200	200 - 400
Acetylene (C_2H_2)	20 - 30	30 - 50	100 - 150
Carbon Monoxide (CO)	200 - 300	400 - 500	600 - 700
Carbon Di-oxide (CO_2)	3000 - 3500	4000 - 5000	9000 - 12000

Technique - 2 : Total Combustible Gas (TCG) Method

Probability of any incipient fault can be anticipated from the total concentration of dissolved combustible gases i.e. by adding the concentrations of H_2, CH_4, C_2H_6, C_2H_4, C_2H_2 and CO.

Combustible Gas (in ppm)	Transformer Condition
0 - 500	Satisfactory.
500 - 1000	Decomposition of oil in excess of normal aging; needs monitoring.
> 1000	Significant decomposition of oil; needs close monitoring.
> 2500	Substantial decomposition of oil; needs inspection to detect fault.

Technique - 3 : Key Gas Method

Gas	Nature of Fault
Methane (CH_4) & Ethane (C_2H_6)	Gradual overheating.
CO_2 or CO or both	Transformer overloaded or operating hot.
Ethylene (C_2H_4)	Hot spots in overheated joints, core bolts etc.
Carbon Monoxide (CO)	Overheating involving cellulose insulation.
H_2	Corona discharge, electrolysis of water or rusting.
H_2, CO_2 or CO	Corona discharge involving cellulose or severe overloading.

Technique - 4 : Dornenberg Ratio Method

CH_4 / H_2	C_2H_2 / C_2H_4	C_2H_6 / C_2H_2	C_2H_2 / CH_4	Indication
> 1.0	< 0.75	> 0.4	< 0.3	Thermal decomposition
> 0.1 < 1.0	> 0.75	< 0.4	> 0.3	Electrical discharge
< 0.1	Not significant	> 0.4	< 0.3	Corona

Technique - 5 : Roger's Ratio Method

Ratios of gases calculated and are codified as 1, if the ratio is >1 and as 0, if the ratio is <1

CH_4 / H_2	C_2H_6 / CH_4	C_2H_4 / C_2H_6	C_2H_2 / C_2H_4	Indication
0	0	0	0	If $CH_4 / H_2 \leq 0.1$ then P.D., otherwise normal
1	0	0	0	Slight overheating (< 150 °C)
1	1	0	0	Overheating (150 - 200 °C)
0	1	0	0	Overheating (200 - 300 °C)
0	0	1	0	General conductor overheating
1	0	1	0	Circulating currents and / or overheated joints
0	0	0	1	Flashover without power follow-through
0	1	0	1	Tap-changer selector breaking current
0	0	1	1	Arc with power follow-through or persistent arcing

Technique - 6 : IEC Ratio Method

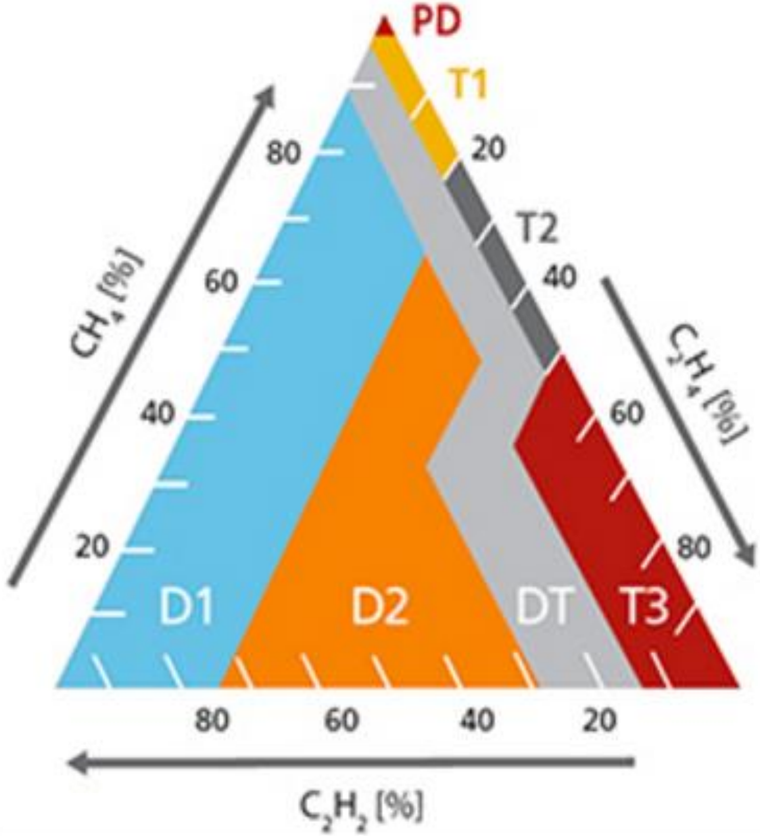
Ratios of gases calculated and are codified as mentioned in the chart.

	C_2H_2 / C_2H_4	CH_4 / H_2	C_2H_4 / C_2H_6	
Ratio of gases < 0.1 0.1 to 1 1 to 3 > 3	 Code 0 Code 1 Code 1 Code 2	 Code 1 Code 0 Code 2 Code 2	 Code 0 Code 0 Code 1 Code 2	
				Indication
Code :	0	0	0	Normal
Code :	0	1	0	Partial discharges of low energy density
Code :	1	1	0	Partial discharges of high energy density
Code :	1 → 2	0	1 → 2	Discharges of low energy
Code :	1	0	2	Discharges of high energy
Code :	0	0	1	Thermal fault of temperature (< 150 ^{o}C)
Code :	0	2	0	Thermal fault of temp. (150 - 300 ^{o}C)
Code :	0	2	1	Thermal fault of temp. (300 - 700 ^{o}C)
Code :	0	2	2	Thermal fault of temperature (> 700 ^{o}C)

RP - Sanjiv Goenka Group
Growing Legacies

CESC LIMITED
Energising Lives • Since 1899

DUVAL TRIANGLE (IEC 60599-2007-05)



ZONE	FAULT INDICATION
T1	Thermal fault, ≤300 °C
T2	Thermal fault, >300 °C, ≤700 °C
T3	Thermal fault, >700 °C
D1	Discharges of low-energy
D2	Discharges of high-energy
DT	Combination of thermal faults and discharges
PD	Partial discharge

RP-Sanjiv Goenka Group
Growing Legacies

CESC LIMITED
Energising Lives • Since 1899

CESC LIMITED

DGA DASHBOARD

ZONE   QUERY & REPORTS

SOUTH WEST ZONE

SUBSTATION

CHAKMIR S/S | MAJERHAT S/S

RECEIVING STATION

SOUTHERN R/S

DISTRIBUTION STATION

AKRA D/S	ALIPORE D/S	BARISHA D/S	BEHALA D/S	BEHALA NORTH D/S	BHOWANIPORE D/S	BUDGE BUDGE D/S	BUDGE BUDGE SOUTH D/S
DIAMOND CITY WEST DS (SARSUNA)	EDEN CITY D/S	ELGIN ROAD D/S	GANGARAMPORE D/S	GARDEN REACH D/S	HIDE ROAD D/S	KIDDIRPORE D/S	MAHESHTOLA D/S
MAJERHAT D/S	PRINCE ANWAR SHAH D/S	RAJA SANTOSH ROAD D/S	SIRITY D/S	SOUTHERN D/S	TARATALA D/S	THAKURPUKUR D/S	TOLLYGUNGE NORTH D/S

Station : SOUTHERN R/S   Zone : SOUTH WEST ZONE

TRANSFORMERS

A600028A
(T-1 75MVA)

A600030A
(T-3 55MVA)

A600035A
(T-2 55MVA)

C500031A
(EARTHING TR
ET-2)

NO IMAGE

C500034A
(EARTHING TR
ET-1)

NO IMAGE

Legends : Power Tr. | Earthing Tr.

RP-Sanjiv Goenka Group
Growing Legacies

CESC LIMITED
Energising Lives • Since 1899

DGA DASHBOARD - GENERAL INFORMATION

Asset No. : A600030A

Asset Category : 132/33 kV POWER TRANSFORMER

Asset Name : SOUTHERN R/S T-3 55MVA

Make : CA PARSONS

Capacity (MVA) : 55

Voltage Ratio : 132/33

1st Comm. Date : 22/08/1996

Status as per Last DGA Values : GREEN

DGA DETAILS

Total Records Found : 33

Sample ID	Sampling Date	CH4	C2H6	C2H4	C2H2	H2	CO2	CO	Sampling Reasons	Tick to Select
238118	12/12/16	3	1	3	0	9	5640	213	ROUTINE SAMPLING	☐
226734	24/06/16	2	0	2	0	3	3005	222	ROUTINE SAMPLING	☐
219364	07/03/16	2	1	1	0	13	3571	127	ROUTINE SAMPLING	☐
200217	05/09/15	1	0	1	0	17	2419	85	ROUTINE SAMPLING	☐
171224	21/01/15	2	0	1	0	0	1050	41	ROUTINE SAMPLING	☐
147188	16/06/14	3	0	0	0	6	5126	238	ROUTINE SAMPLING	☐
116264	18/11/13	2	2	3	0	1	4462	155	ROUTINE SAMPLING	☐

Show Interpretation | Show Duval Triangle | Show Trend Analysis | Export to Excel | Close

DGA INTERPRETATION REPORT

Asset No. : **A600030A**
Asset Category : **132/33 kV POWER TRANSFORMER**
Asset Name : **SOUTHERN R/S T-3 55MVA**
Sampling Date : **12/12/16** **Sample ID : 238118**

Make : **CA PARSONS**
Capacity (MVA) : **55**
Voltage Ratio : **132/33**
1st Comm. Date : **22/08/1996**
Status as per the Current DGA Values : GREEN

IEC Reference : (View Guidelines)

Thermal Fault of Low Temperature < 150 degC. It is assessed as Condition - 5

Ratios :
C2H2/C2H4 : 0.0 ~ 0
CH4/H2 : 0.33 ~ 0
C2H4/C2H6 : 3.0 ~ 1
Condition : **AMBER**

ROGER'S Ratio : (View Guidelines)

NOT FOUND

Ratios :
CH4/H2 : 0.33 ~ 0
C2H6/CH4 : 0.33 ~ 0
C2H4/C2H6 : 3.0 ~ 2
C2H2/C2H4 : 0.0 ~ 0
Condition :

DORNENBERG Ratio : (View Guidelines)

NOT FOUND

Ratios :
CH4/H2 : 0.33
C2H2/C2H4 : 0.0
C2H2/CH4 : 0.0
C2H6/C2H2 : 0.0
Condition :

KEY GAS METHOD : (View Guidelines)

Overheating involving cellulose.

Values (ppm) :
CH4 : 3
C2H6 : 1
C2H4 : 3
C2H2 : 0
H2 : 9
CO : 213
Condition : **AMBER**

COMBUSTIBLE GAS METHOD : (View Guidelines)

Satisfactory.

Total (ppm)
229
Condition : **GREEN**

PERMISSIBLE CONCENTRATION (View Guidelines)
GAS METHOD : Age as on date of sampling : **20 yrs**

GAS	Limit (> 10 yrs)	Value (ppm)
H2	200-300	9
CH4	200-300	3
C2H6	800-1000	1
C2H4	200-400	3
C2H2	100-150	0
CO	600-700	213
CO2	9000-10000	5640

Publishers' Remarks :

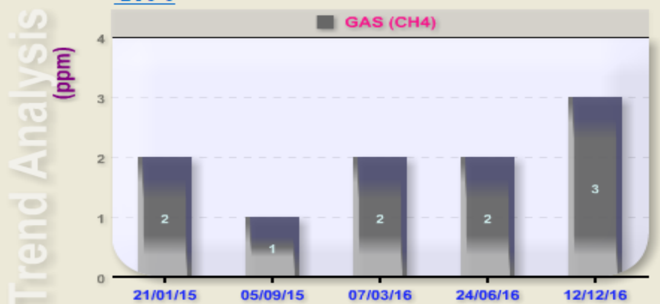
Show Duval Triangle | Show Trend Analysis | Save as PDF | Close

Asset No.	:	**A600030A**
Asset Category	:	**132/33 kV POWER TRANSFORMER**
Asset Name	:	**SOUTHERN R/S T-3 55MVA**

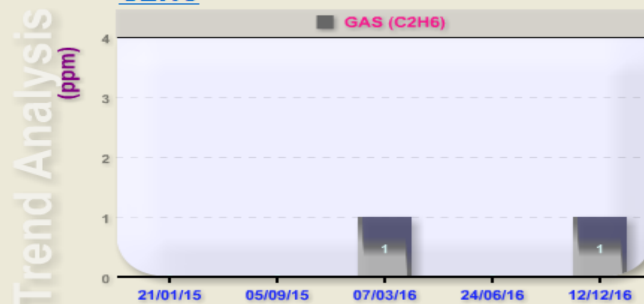
Close

DGA - GAS TREND ANALYSIS

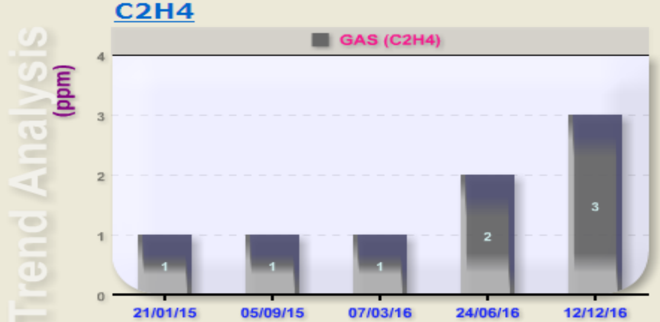
CH4



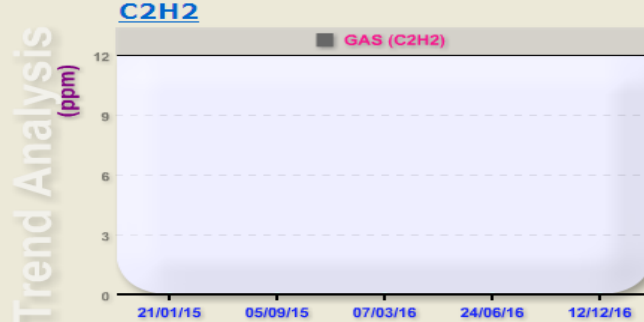
C2H6



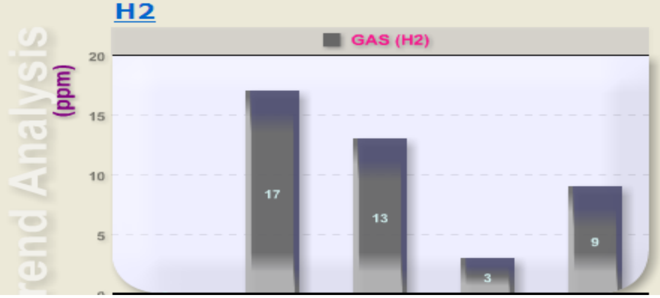
C2H4



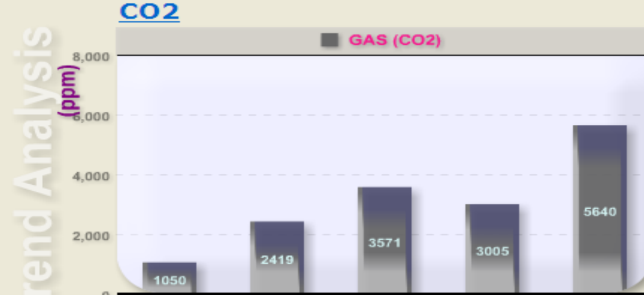
C2H2



H2

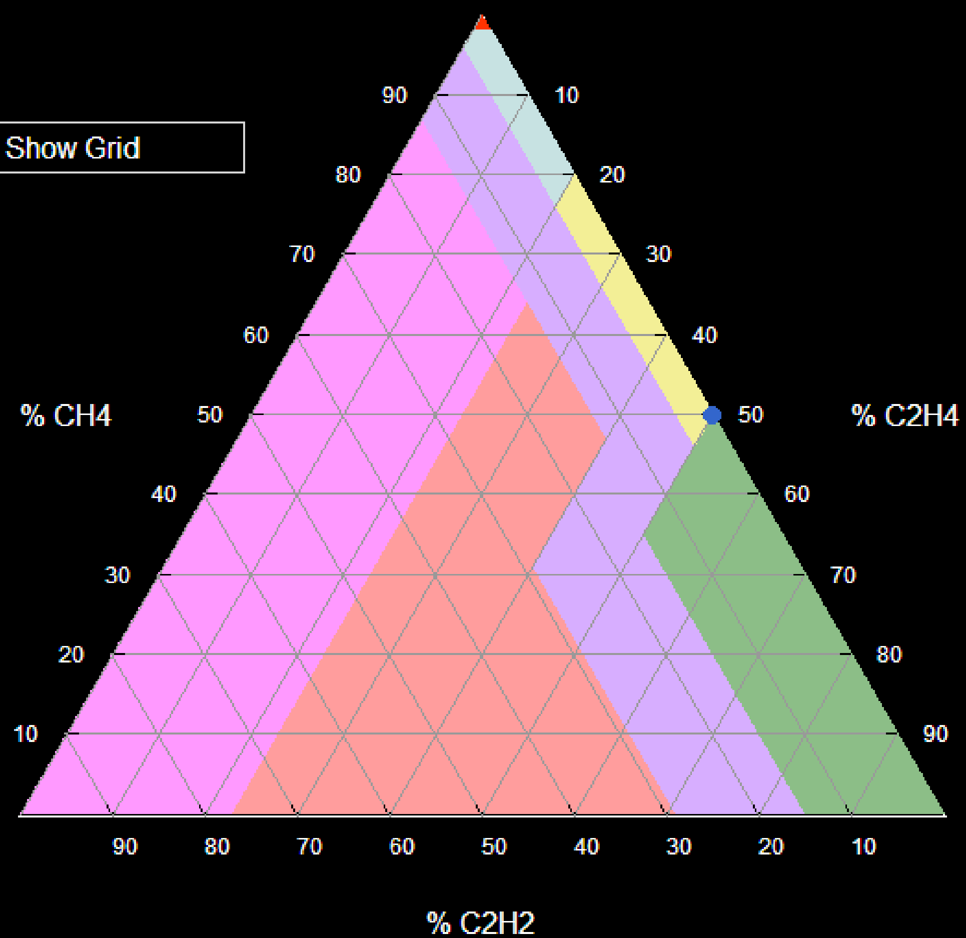


CO2



IEC 60599 Duval's Triangle Graphical Representation of Gas Ratios

Show Grid



Asset No : A600030A

132/33 kV POWER TRANSFORMER

SOUTHERN R/S T-3 55MVA

EXIT

			%C2H2	%CH4	%C2H4
Sample Dt. 1	●	12-12-16	0	50	50

	Discharges of Low Energy
	Discharges of High Energy
	Thermal Fault (t < 300 Deg)
	Thermal Fault (300 Deg < t < 700 Deg)
	Thermal Fault (t > 700 Deg)
	Multiple Faults or High Background gases
	Corona Partial discharges

DGA Case Studies

Case – 1 Transformer No. T-2 at Rashbehari Distribution Station

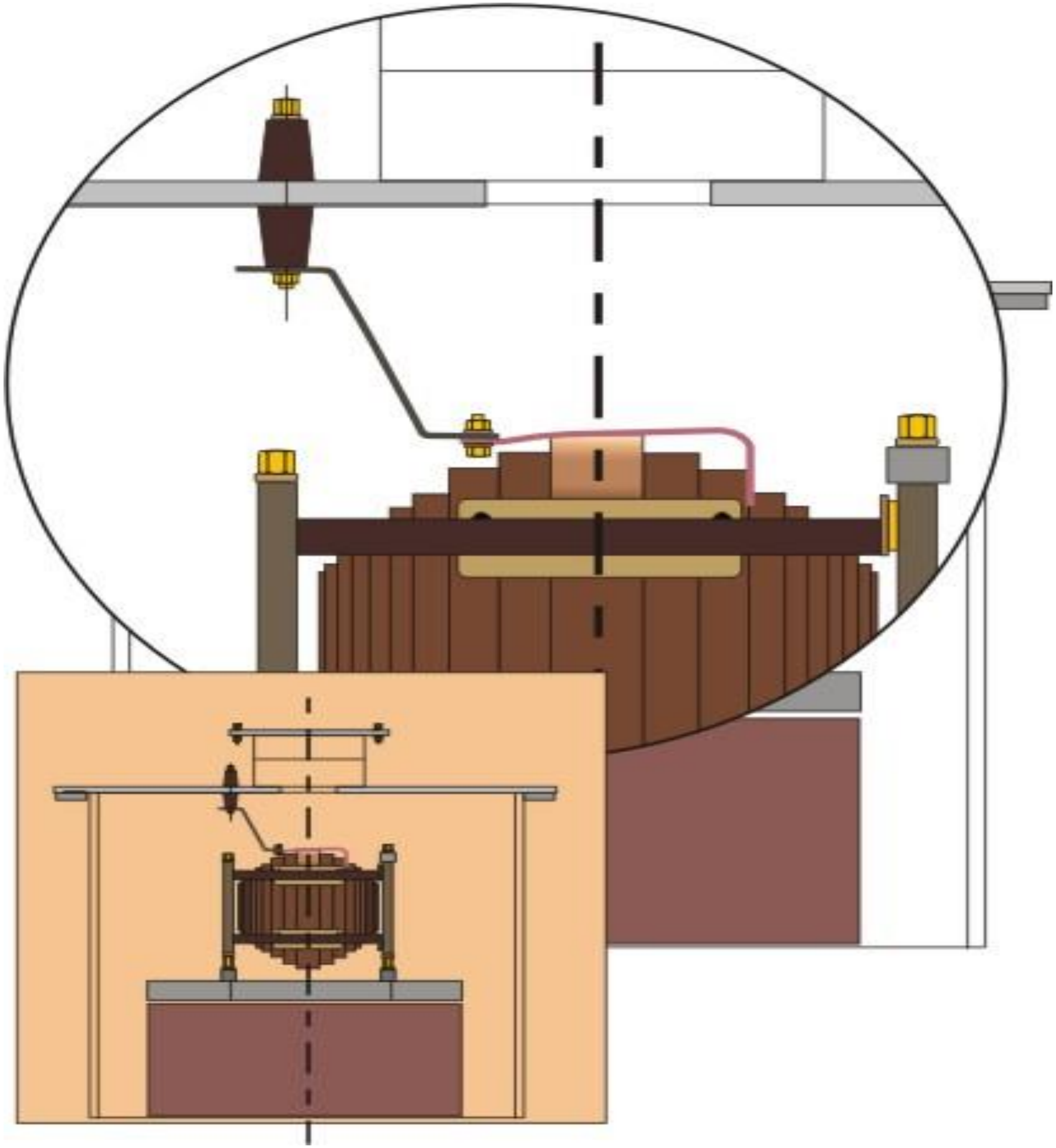
Capacity: 16 MVA kV: 33/11-6 Commissioned on: 27/3/02

History : The transformer was uprated by replacing core and providing new winding and commissioned on 27/3/02. DGA results of samples taken at different times are:

Date	H_2 (ppm)	CH_4 (ppm)	C_2H_6 (ppm)	C_2H_4 (ppm)	C_2H_2 (ppm)	CO (ppm)	CO_2 (ppm)	Remarks
26/3/02	0	0	0	0	0	2	148	Before pre-comm. h.v. test
26/3/02	0	0	0	0	0	4	157	After pre-comm. h.v. test
27/3/02	0	0	0	0	0	6	188	Pre-comm. check
27/3/02	0	0	0	0	0	10	241	Post comm. check
27/5/02	90	244	86	370	0	13	181	Monitoring after 2 months
19/8/02	73	297	114	445	0	14	146	Close monitoring
30/12/02	84	483	184	729	0	27	297	Close monitoring
13/5/03	204	475	241	265	1	58	620	Close monitoring

Since the concentration of different gases were increasing rapidly and interpretation by the different methods were indicating some internal abnormality, as indicated below, the transformer was taken out of service on 28/10/03 and sent to the repairer's works for internal inspection.

Interpretations as per	Sampling on 13/5/03
Permissible concentration of gases	H_2, CH_4, C_2H_6 and C_2H_4 are exceeding limit.
Total combustible gas	1244 ppm; indicating significant decomposition of oil.
Key gas method	H_2 & CH_4 along with C_2H_6 and C_2H_4; indicating sparking or other minor fault causing breakdown of oil.
Dornenberg ratio	>1, < 0.75, >0.4, <0.3; indicating thermal decomposition.
Rogers ratio	1, 0, 1, 0; indicating circulating currents and / or overheated joints.
IEC ratio	0, 2, 1; indicating thermal fault of temperature (300 - 700 ^oC).



Case – 2 Transformer No. T-1 at Auckland Square Distribution Station

Capacity: 20 MVA kV: 33/11-6 Commissioned on: 03/07/95

History: The Transformer tripped through the operation of Buchholz and Differential Relays on 22/09/2009. All conventional LV & HV tests, including sampling of trapped gas in Buchholz Relay, were carried out for the Transformer but no abnormality was found. The Transformer was re-commissioned. Post tripping oil sampling was carried out for DGA, which showed abnormally high concentration of Hydrogen (H_2) and Acetylene (C_2H_2) gases in the oil, compared to the previous test results suggesting 'High Energy Arcing within Oil inside the Transformer'.

The Transformer was then subjected to more frequent monitoring through DGA on daily basis for the next 9 days till 01/10/2009 and oil samples were taken in various conditions of the Transformer i.e. running the Transformer both in On-load and Off-load conditions for prolonged period to observe whether load had any adverse effect on the Transformer, owing to development of any high-resistance spot/joint on the conducting path. Nevertheless, the DGA results showed similar high concentrations of Hydrogen (H_2) and Acetylene (C_2H_2) irrespective of the loading conditions suggesting presence of persistent 'High Energy Arcing within Oil inside the Transformer'.

The corresponding DGA results are, as follows:

Date	H_2 (ppm)	CH_4 (ppm)	C_2H_6 (ppm)	C_2H_4 (ppm)	C_2H_2 (ppm)	CO (ppm)	CO_2 (ppm)	Remarks
14/07/2009	17	41	34	5	0	482	4005	Routine Test
22/09/2009	92	65	41	35	89	550	4374	Post tripping
23/09/2009	272	70	34	34	110	491	3832	On load
24/09/2009	356	88	40	43	132	524	4910	On load
27/09/2009	284	80	41	33	125	537	5267	No load
28/09/2009	298	93	41	34	124	555	4929	No load
29/09/2009	247	74	34	26	102	442	4169	On load
01/10/2009	399	81	37	38	105	509	4639	On load

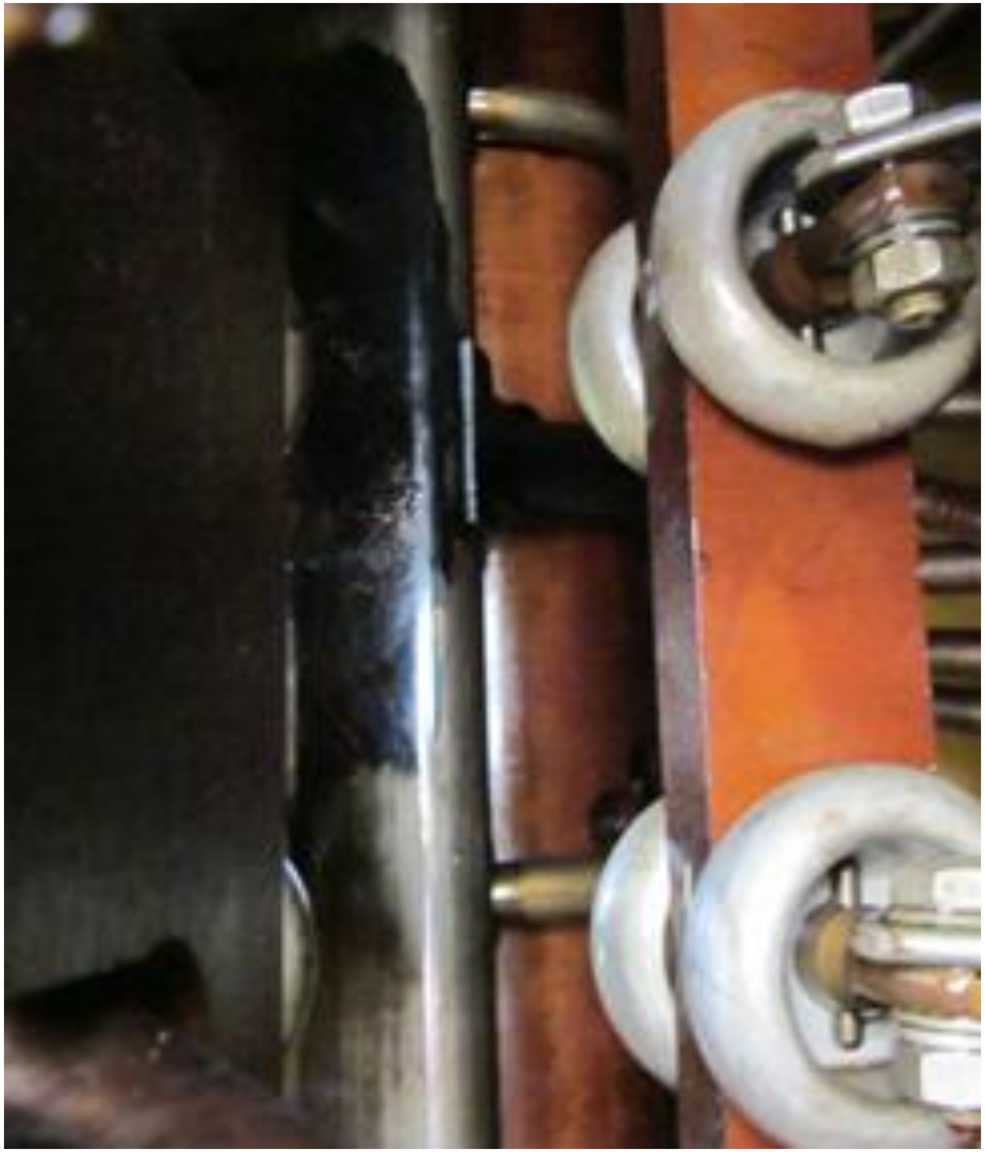
Case – 3 Transformer No. T-3 at East Calcutta 132/33 kV Substation

Capacity: 75 MVA kV: 132/33 Commissioned on: 05/02/2000

History: The transformer was initially commissioned as T-1 at Kasba Receiving Station and subsequently relocated to East Calcutta S/S as T-3 on 09/02/2012. A few days after re-commissioning as East Calcutta S/S T-3, the transformer tripped by operation of Buchholz relay. Although no visual defects were observed and test results also found satisfactory, high gas content was detected in DGA (see the results obtained on 17/02/12). Subsequently, inspection of active parts carried out after draining of main tank oil, when blackening of odd tap collector contact (on center tube) was observed due to excessive heating. The same was developed due to inadequate pressure of the sliding contact. After shifting the contact to the even tap collector ring, winding resistance measurement carried out and the transformer was energized after satisfactory completion of high voltage tests. Dissolved gas content was monitored very closely for the next few days and finally on 01/03/12, the transformer put on load.

Date	H_2 (ppm)	CH_4 (ppm)	C_2H_6 (ppm)	C_2H_4 (ppm)	C_2H_2 (ppm)	CO (ppm)	CO_2 (ppm)	Remarks
13/8/2012	54	66	6	81	0	690	1786	Routine test
1/3/2012	138	75	8	117	46	69	786	Close monitoring
23/2/2012	143	79	9	123	85	55	579	Close monitoring
22/2/2012	53	56	8	105	71	32	627	Others
17/2/2012	272	61	4	59	68	40	311	Post Tripping
9/2/2012	8	0	0	0	0	8	152	Post Commissioning


V1
V2



Thank You

We will now analyse the Questions, still remained Dissolved in your minds

RP- Sanjiv Goenka Group

Growing Legacies

CESC LIMITED

Energising Lives • Since 1899

Asia Institute of Power Management

Communication in Power Utilities

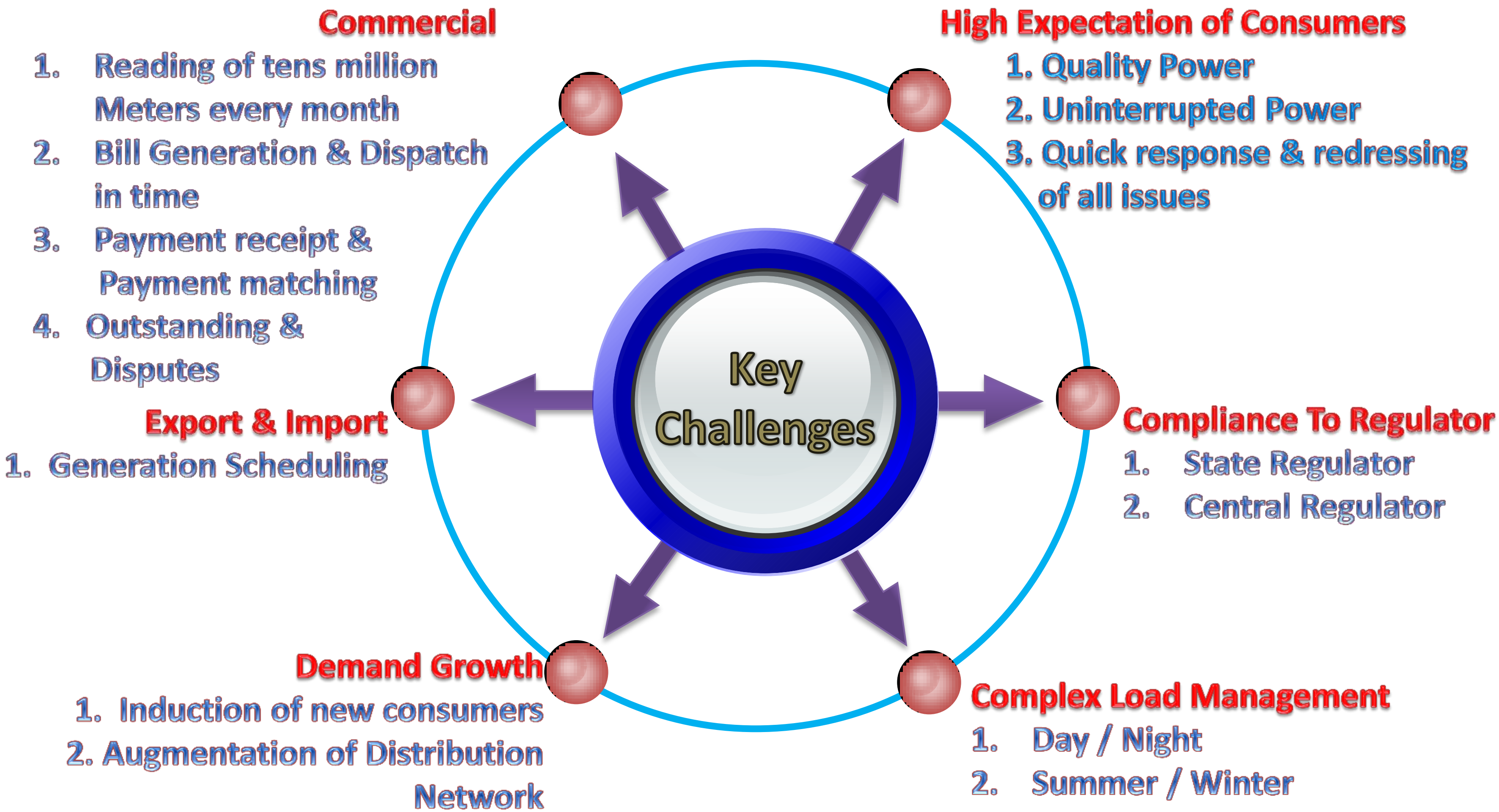
April 2017

Electricity

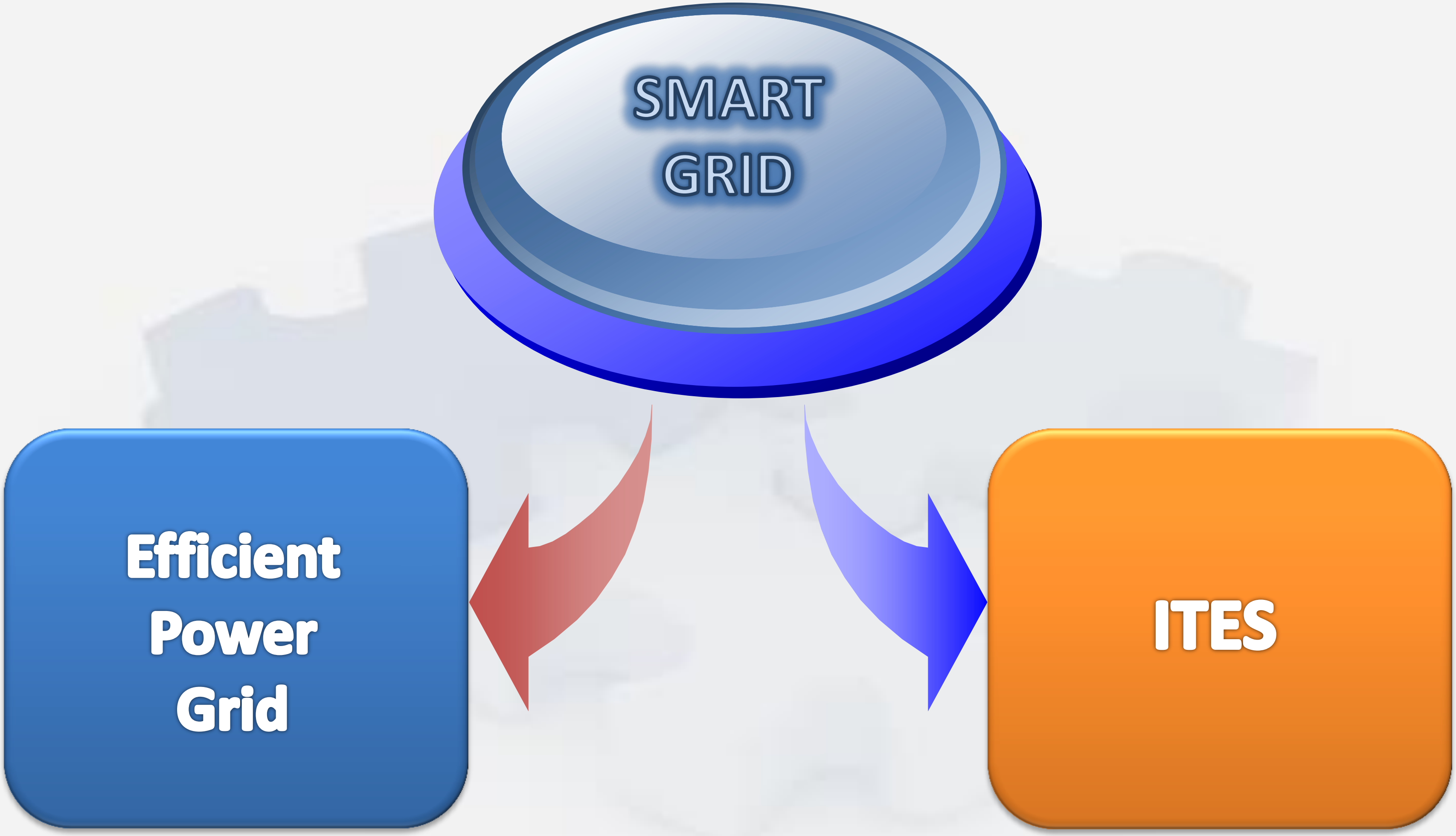
L
I
F
E
L
I
N
E

- Industry
- Transportation
- Agriculture
- Health-Care
- Urban Life & Individuals

Challenges to a Power Utility

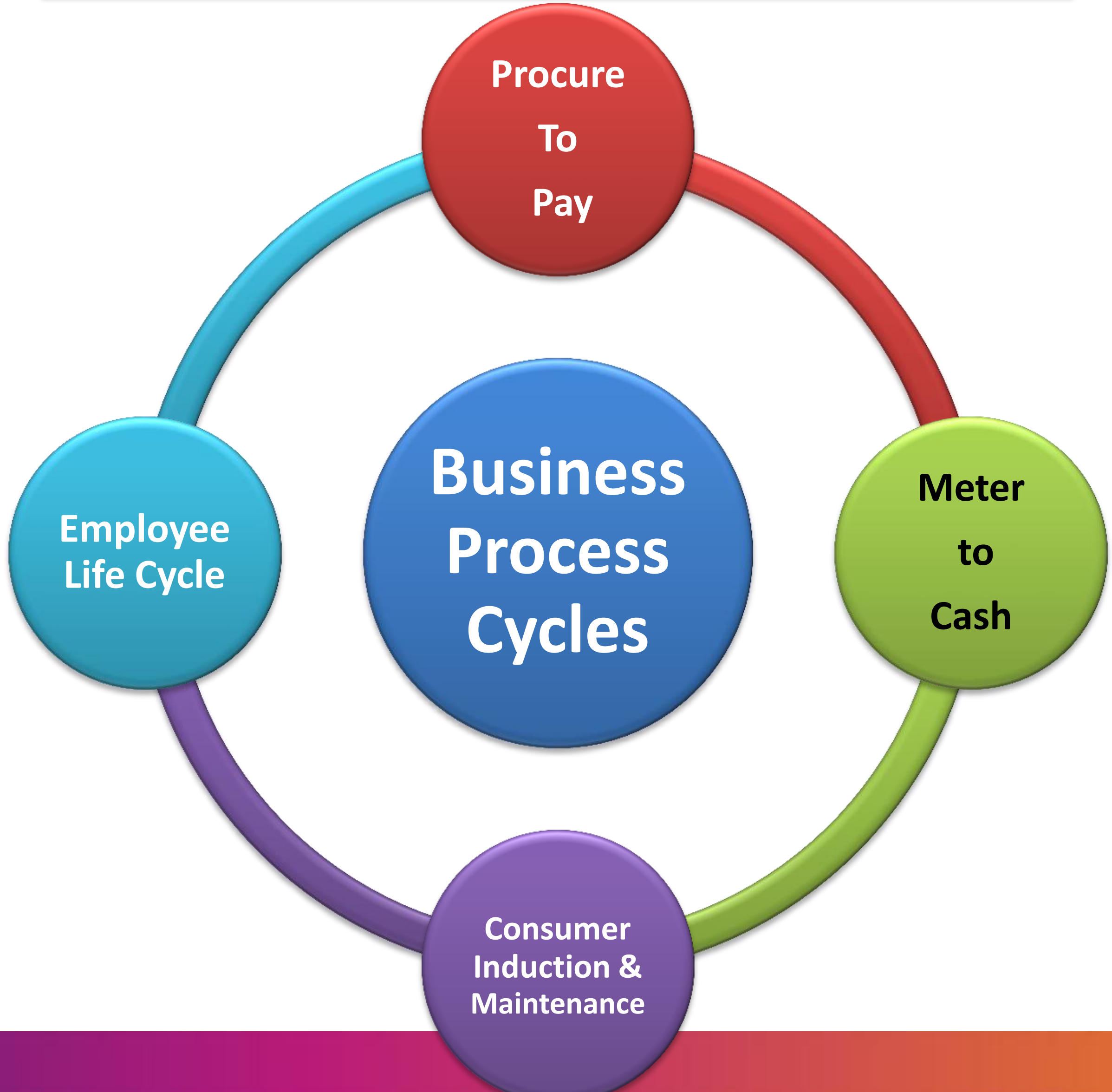


Solution

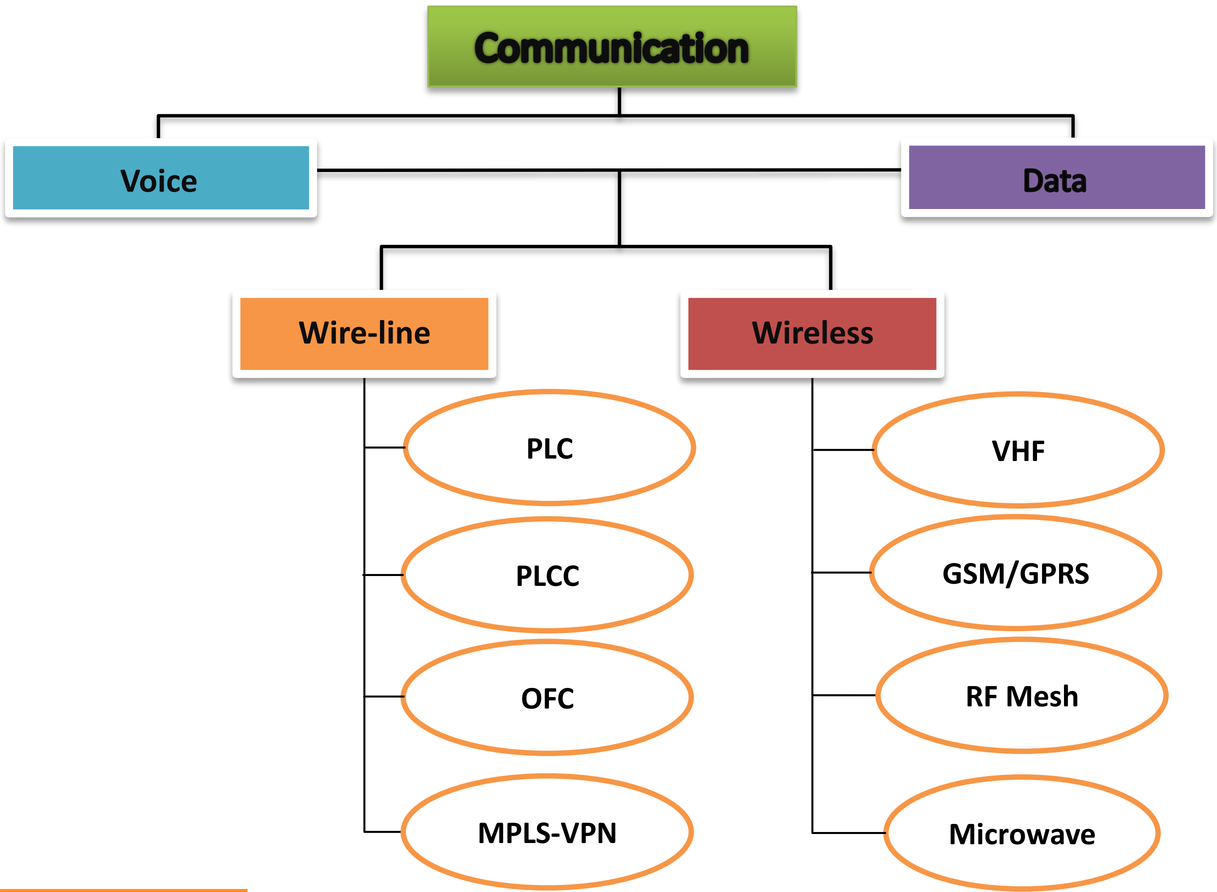


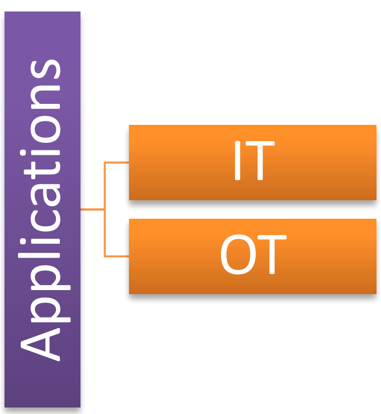
The Smart Grid sits at the intersection of Energy, IT & Telecommunication Technologies

Business Process Cycles of a Power Utility



Communication Systems





Wire-line Media

PLC

- Good solution for applications with low bandwidth requirement
- Not preferable due to reliability based on overhead transmission cables

PLCC

- Not considered in applications of Power Utilities

OFC

- Most reliable and available means of Wire-line Communication Solutions
- High Bandwidth can support any application

MPLS-VPN

- Service Provider dependent
- Can be integrated over long distances

Wireless Media

VHF

- Most popular method of Communication in Power Utilities
- Used for Relaying Alarm Reception in Substations

GSM/GPRS/3G/4G

- Available option for Last-mile Communication Solutions in AMR and DA
- Low Reliability
- Service Provider Dependent

RF Mesh

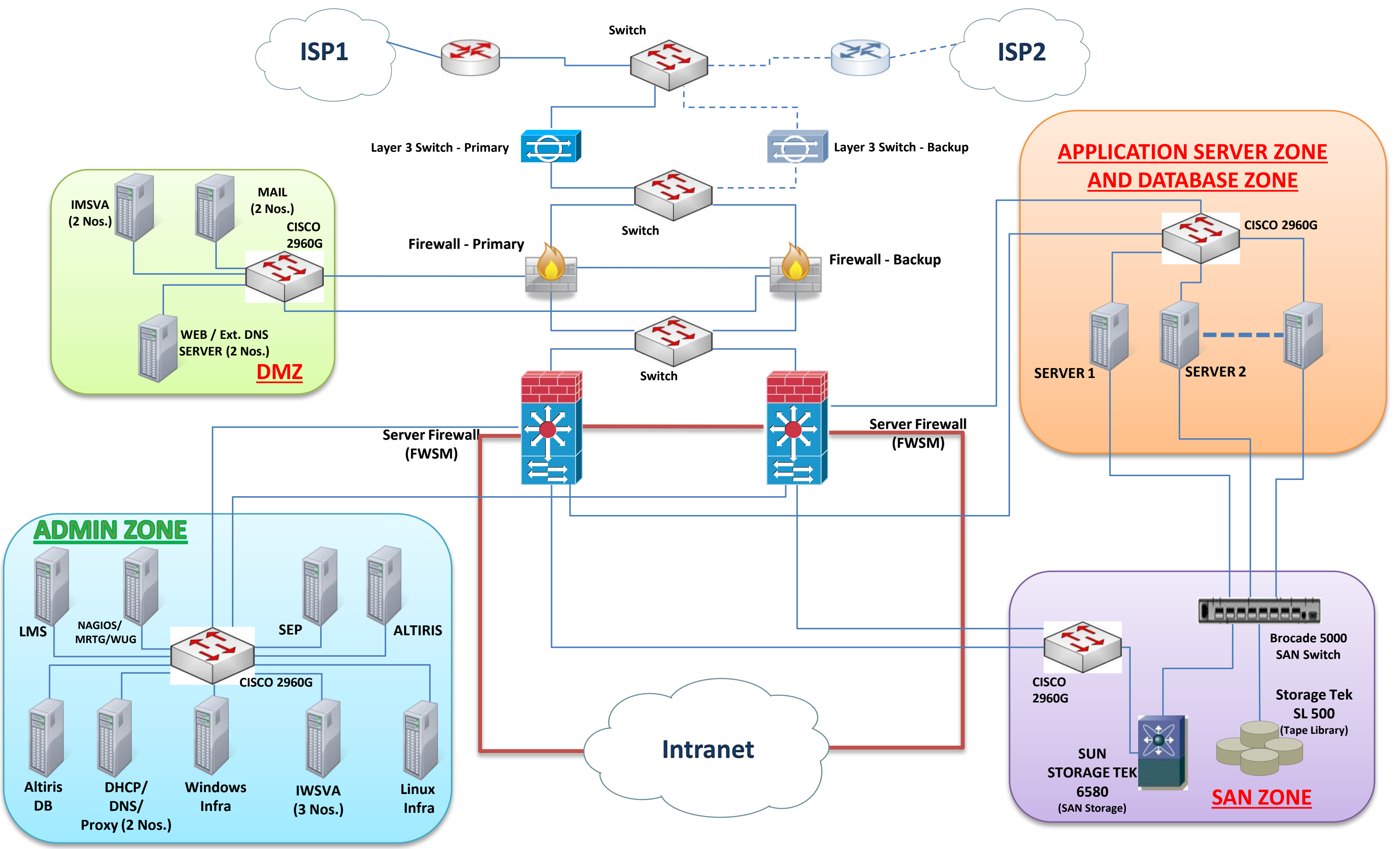
- Emerging Technology among Power Utilities around the World
- Considered for Street Lighting/Switching, AMI and DA
- Availability is based on Frequency Band used

Microwave

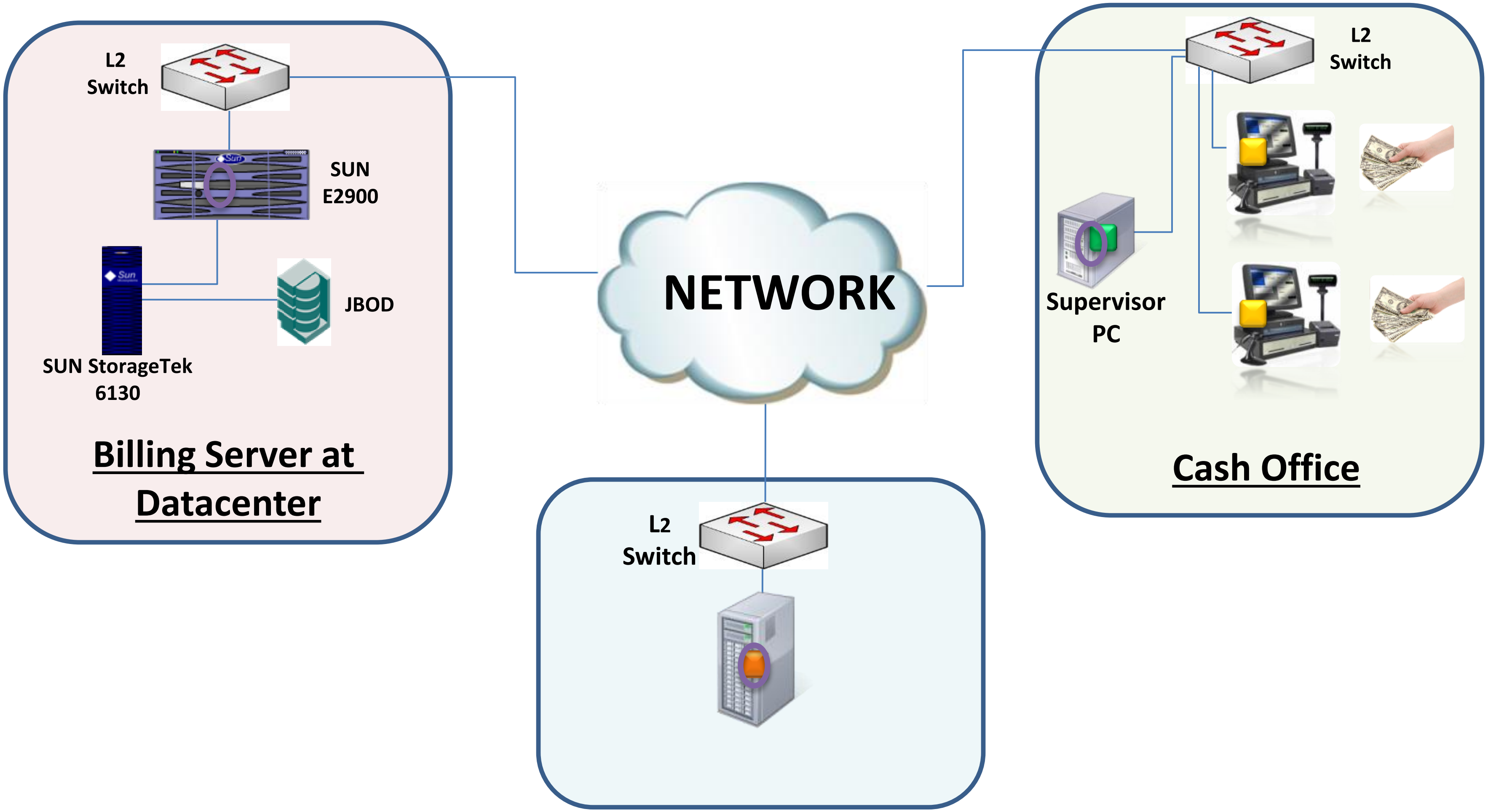
- Regulatory Compliances involved
- Reliability low due to Interference
- Limited Availability of Frequency Spectrum for Power Utilities

Communication in IT Network

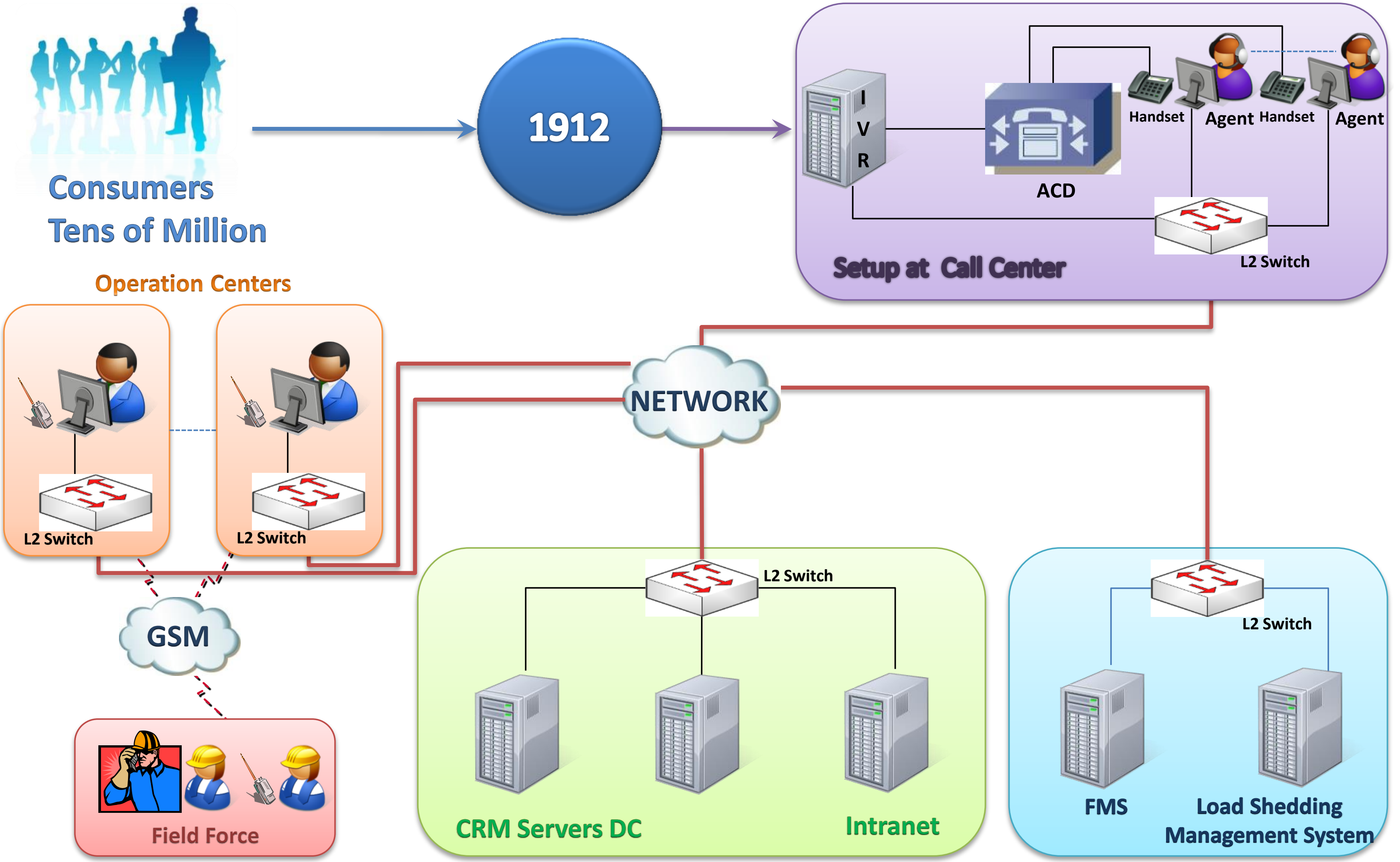
Network Architecture at Data Center



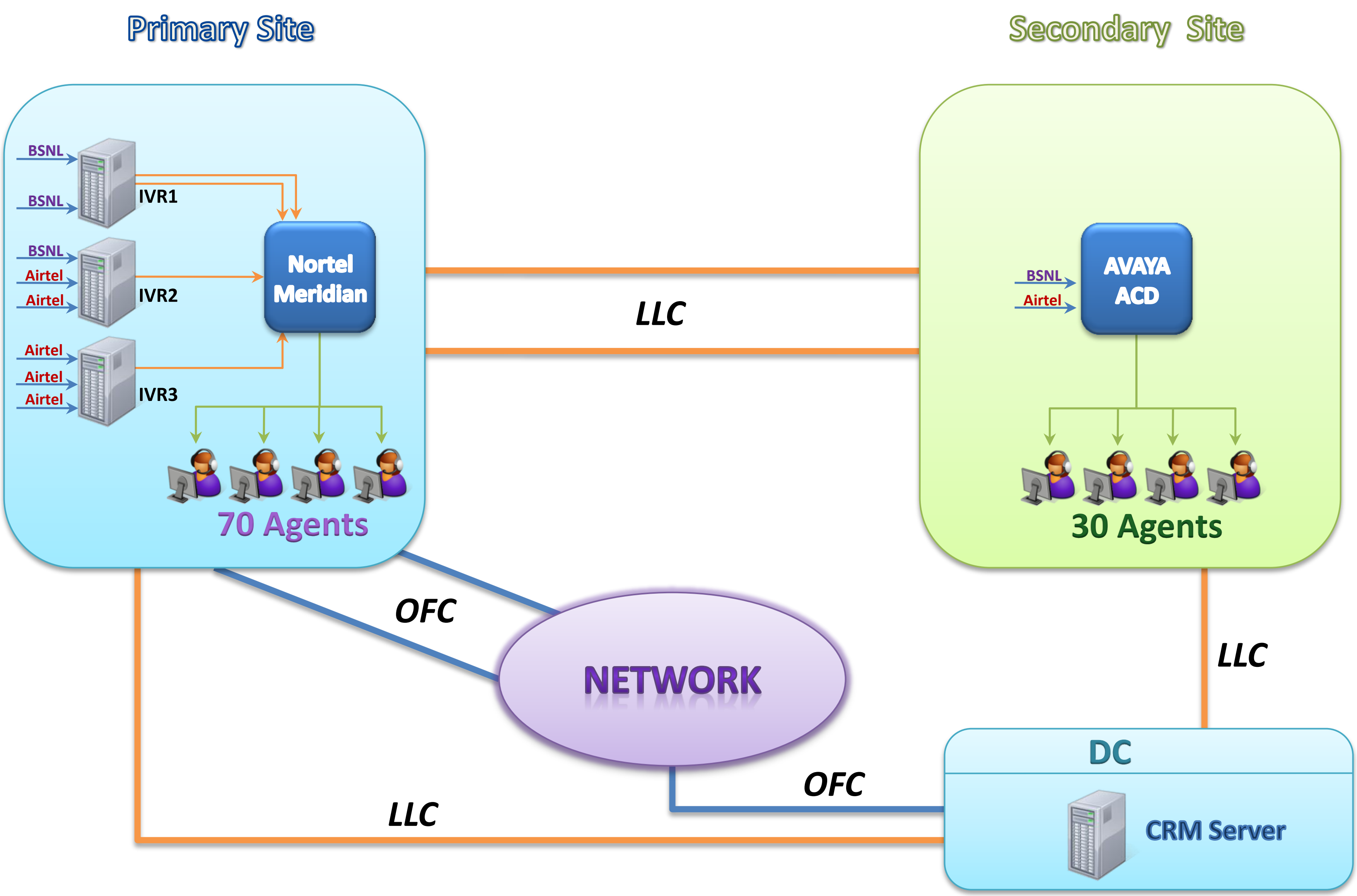
Network Infrastructure for Billing and Treasury Management



Data Connectivity for CRM and Call Centre



Voice Connectivity for CRM and Call Centre



Communication in OT Network

Communication Backbone over SDH for OT

Electrical E1:

At	Card
515 Mux	E1: LOMIF
515T Mux	E1: TM 63E1

Optical STM4:

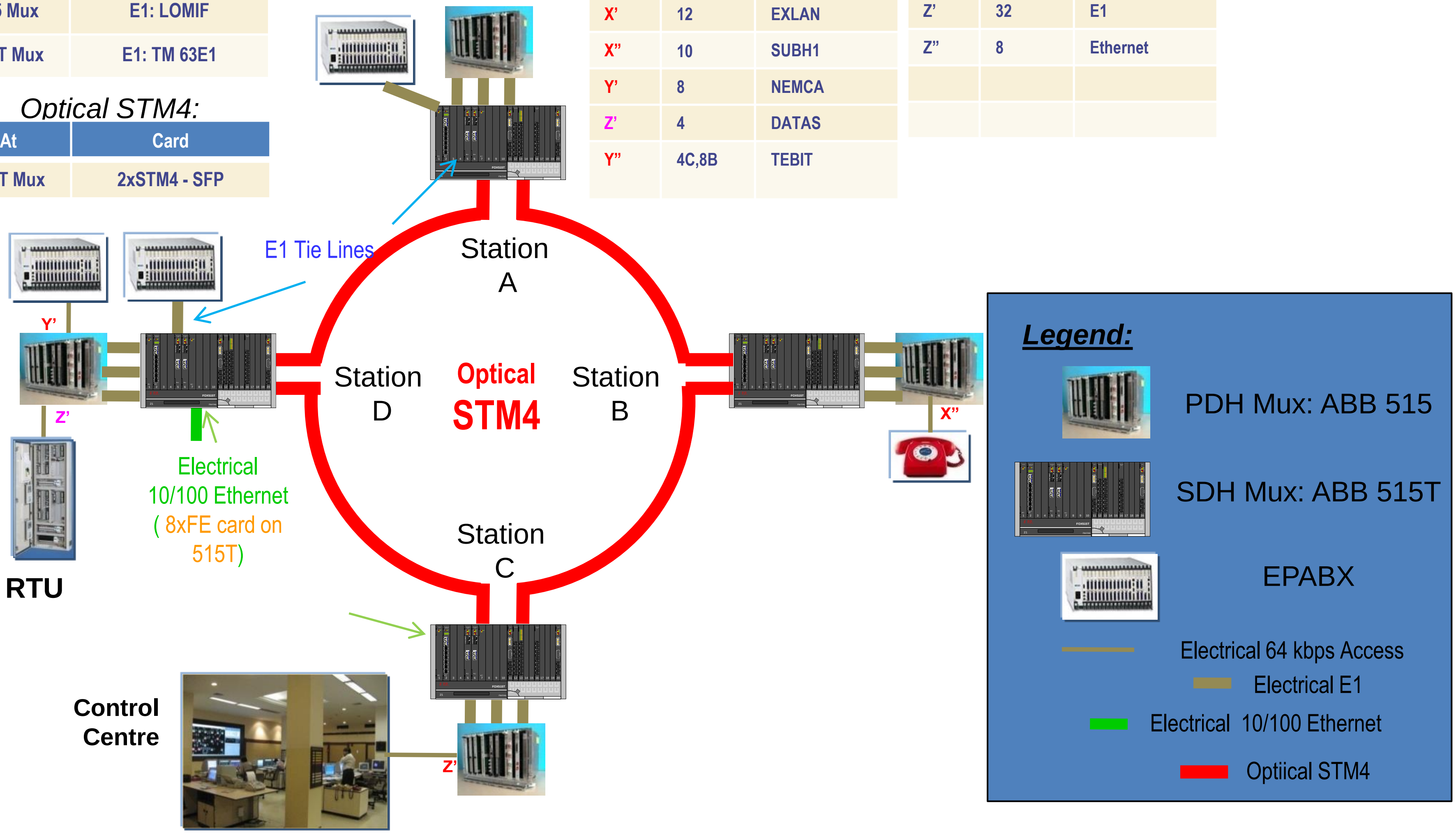
At	Card
515T Mux	2xSTM4 - SFP

Electrical 64 kbps Access(515):

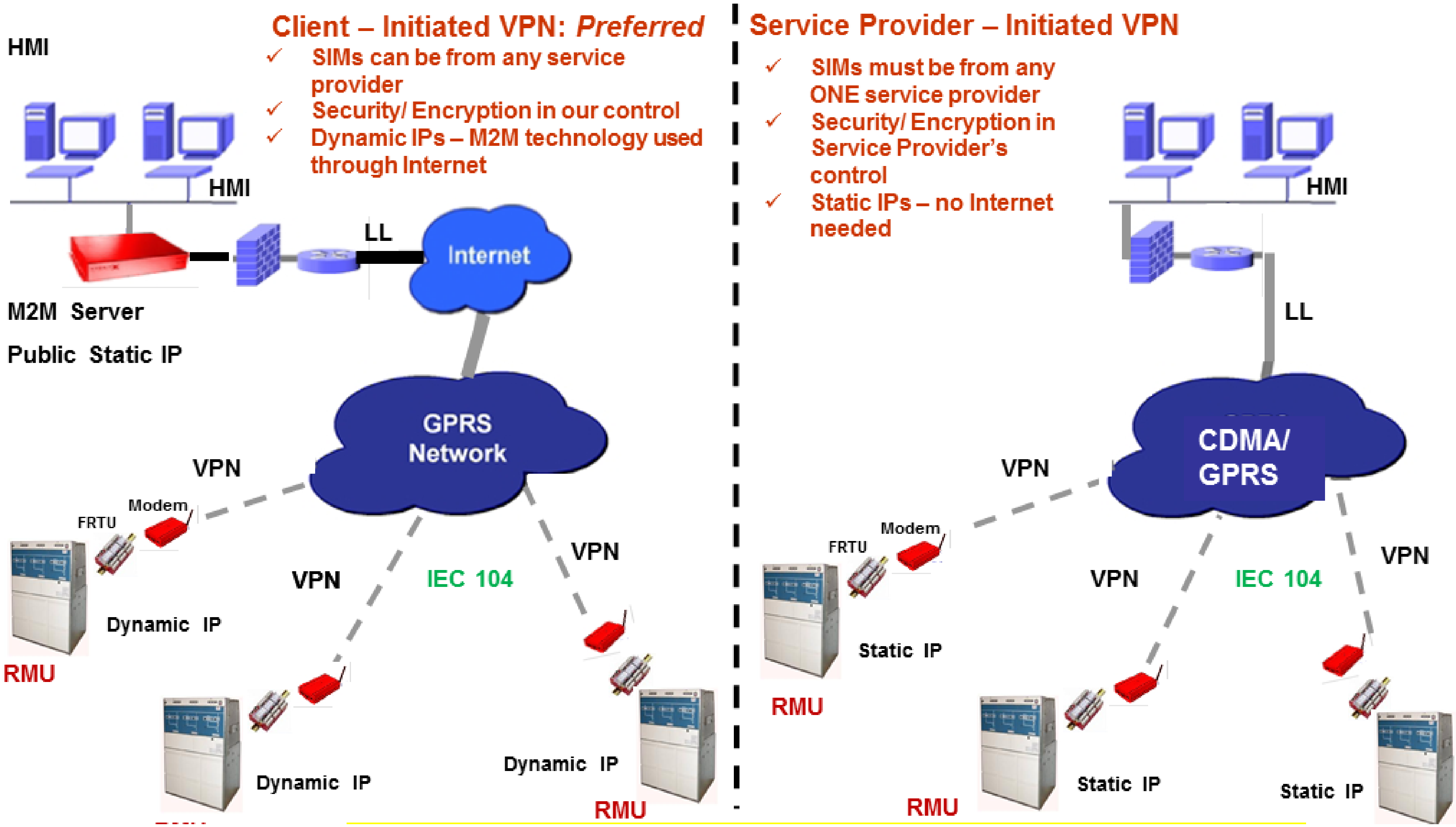
At	Port	515 Interface
X'	12	EXLAN
X"	10	SUBH1
Y'	8	NEMCA
Z'	4	DATAS
Y"	4C,8B	TEBIT

E1& Eth Access(515T):

At	Port	515T Interface
Z'	32	E1
Z"	8	Ethernet

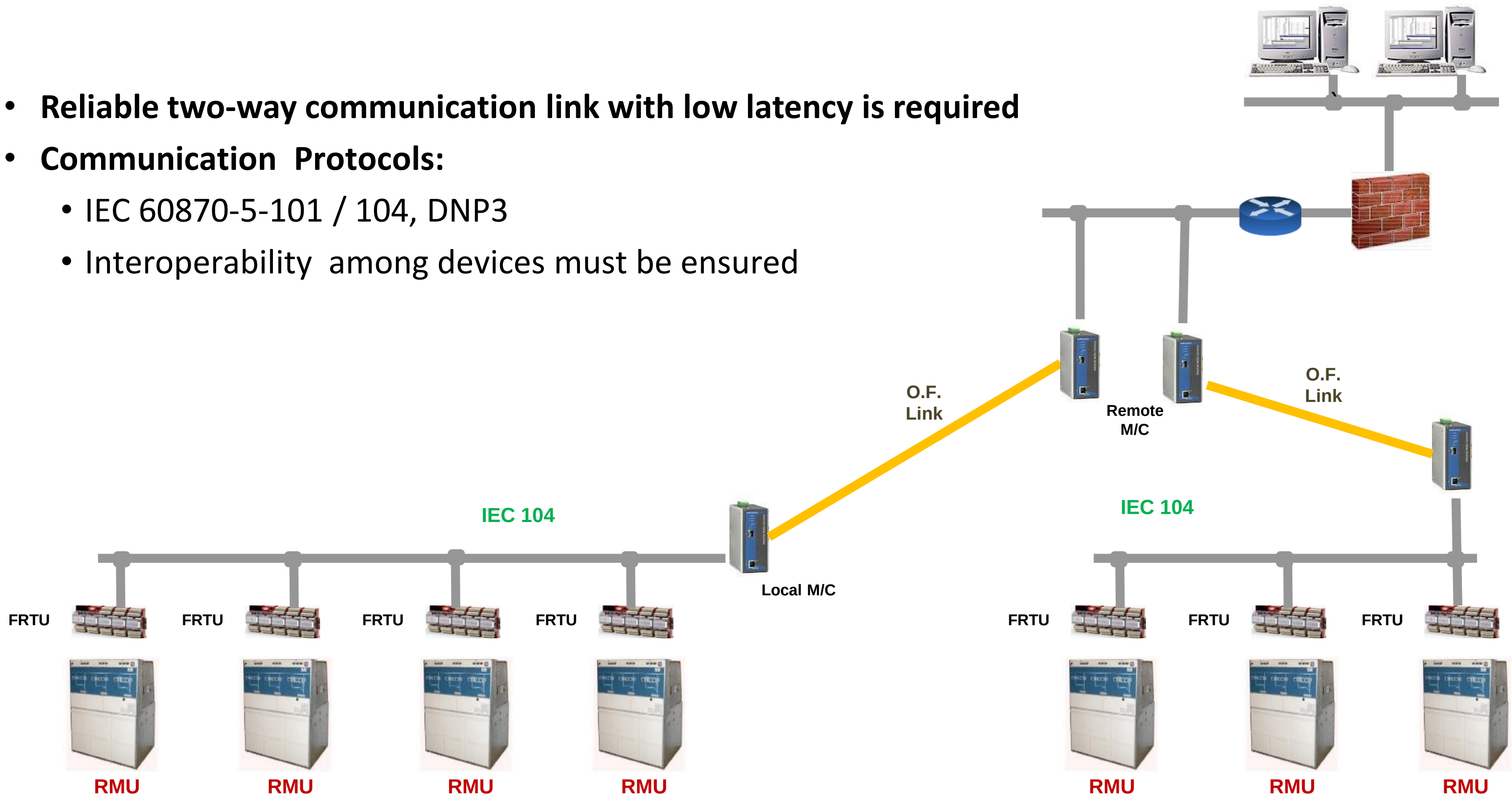


RMU Automation over VPN through GPRS & CDMA

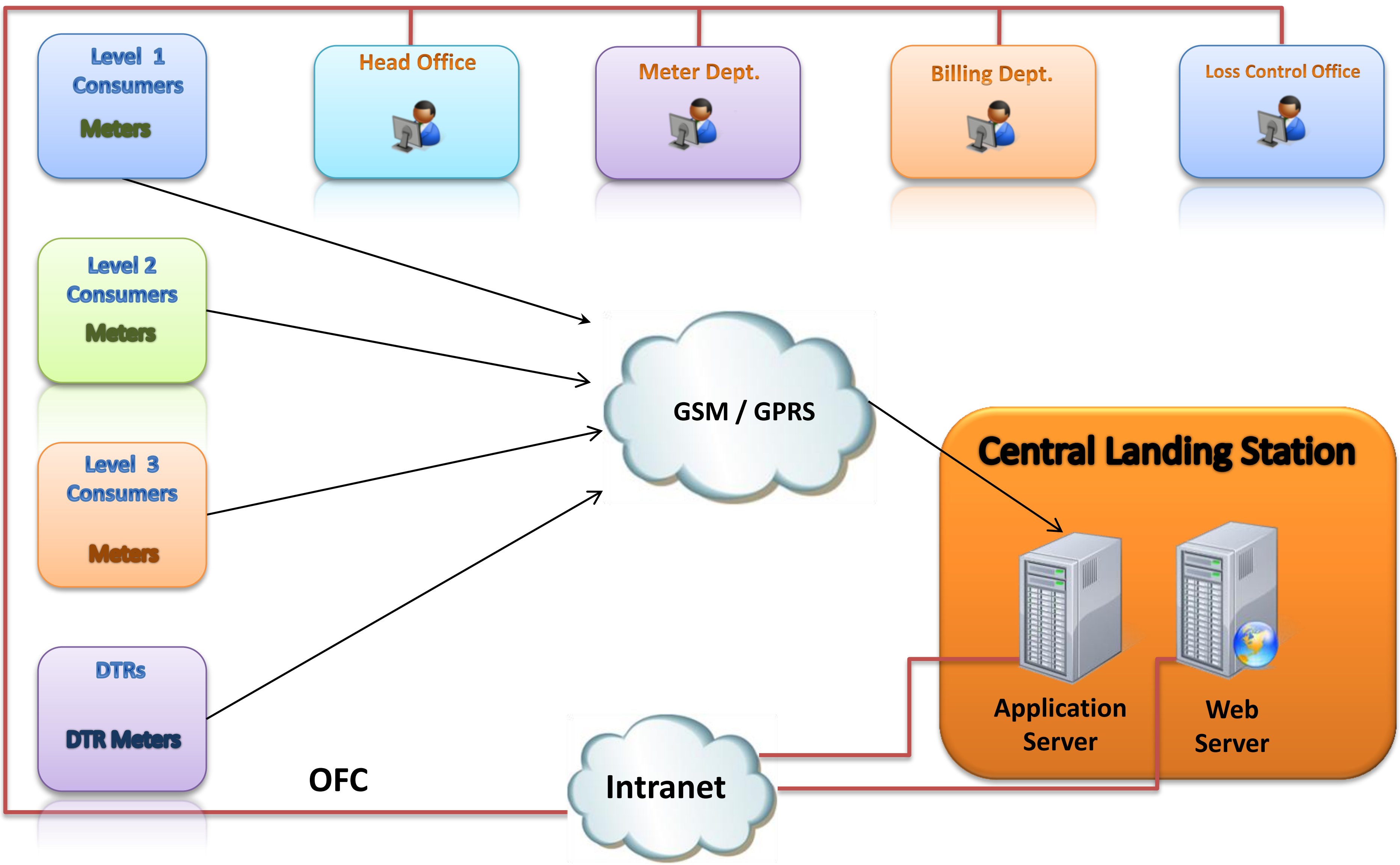


Communication Infrastructure for RMU Automation over OFC – Present Practice

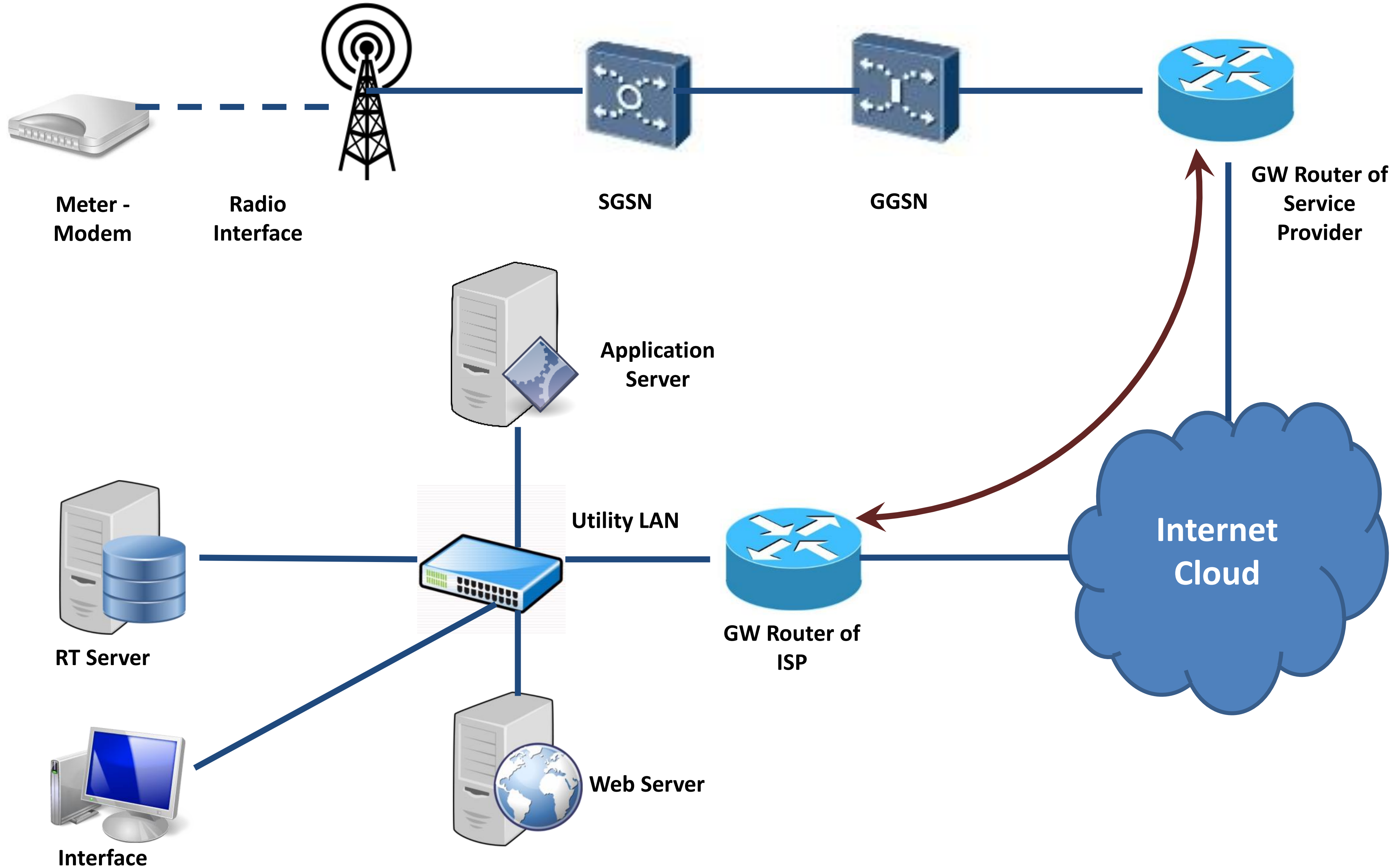
- **Reliable two-way communication link with low latency is required**
- **Communication Protocols:**
  - IEC 60870-5-101 / 104, DNP3
  - Interoperability among devices must be ensured



Communication Schematic for AMR System

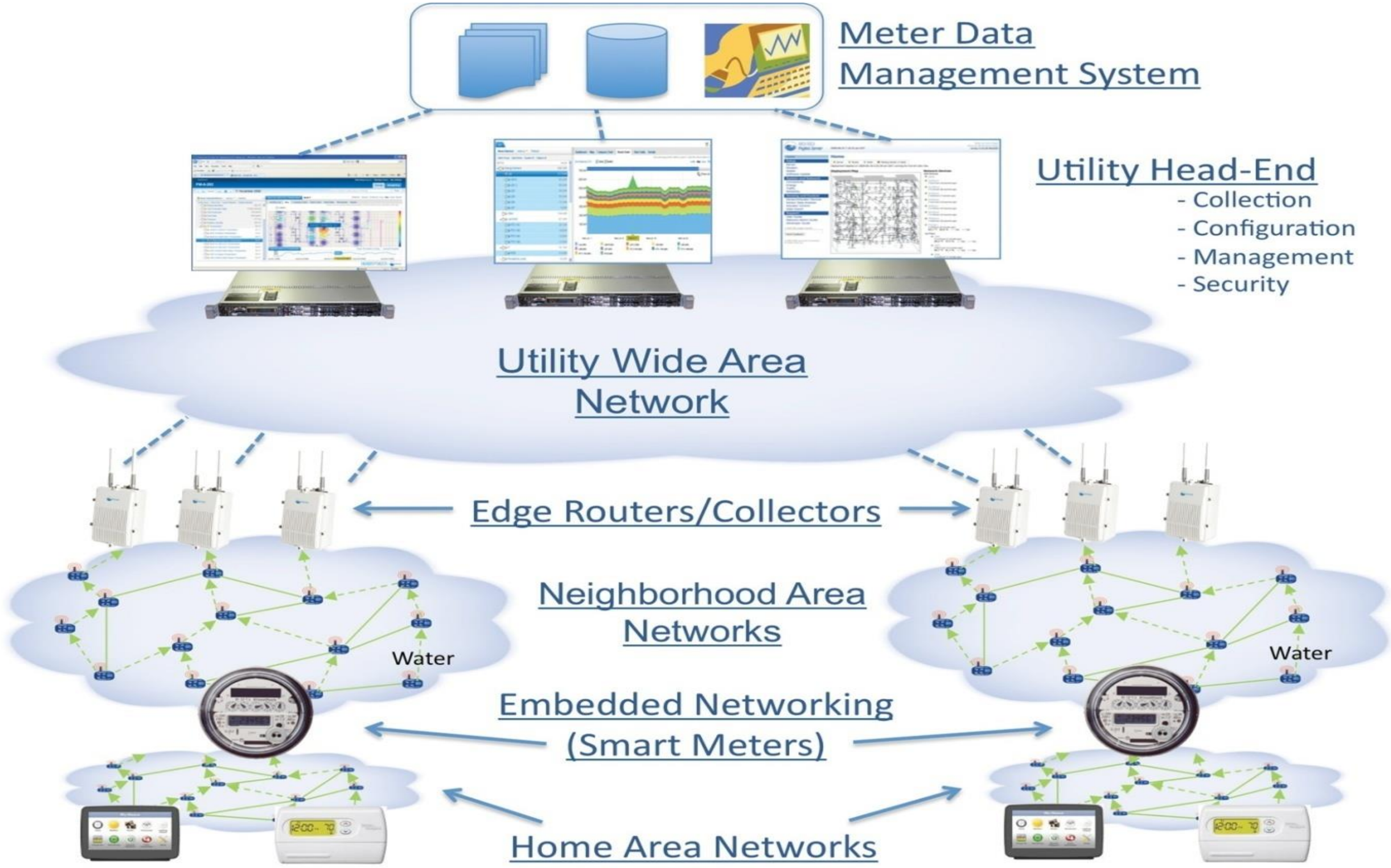


Network Infrastructure for Metering Data Management over GPRS

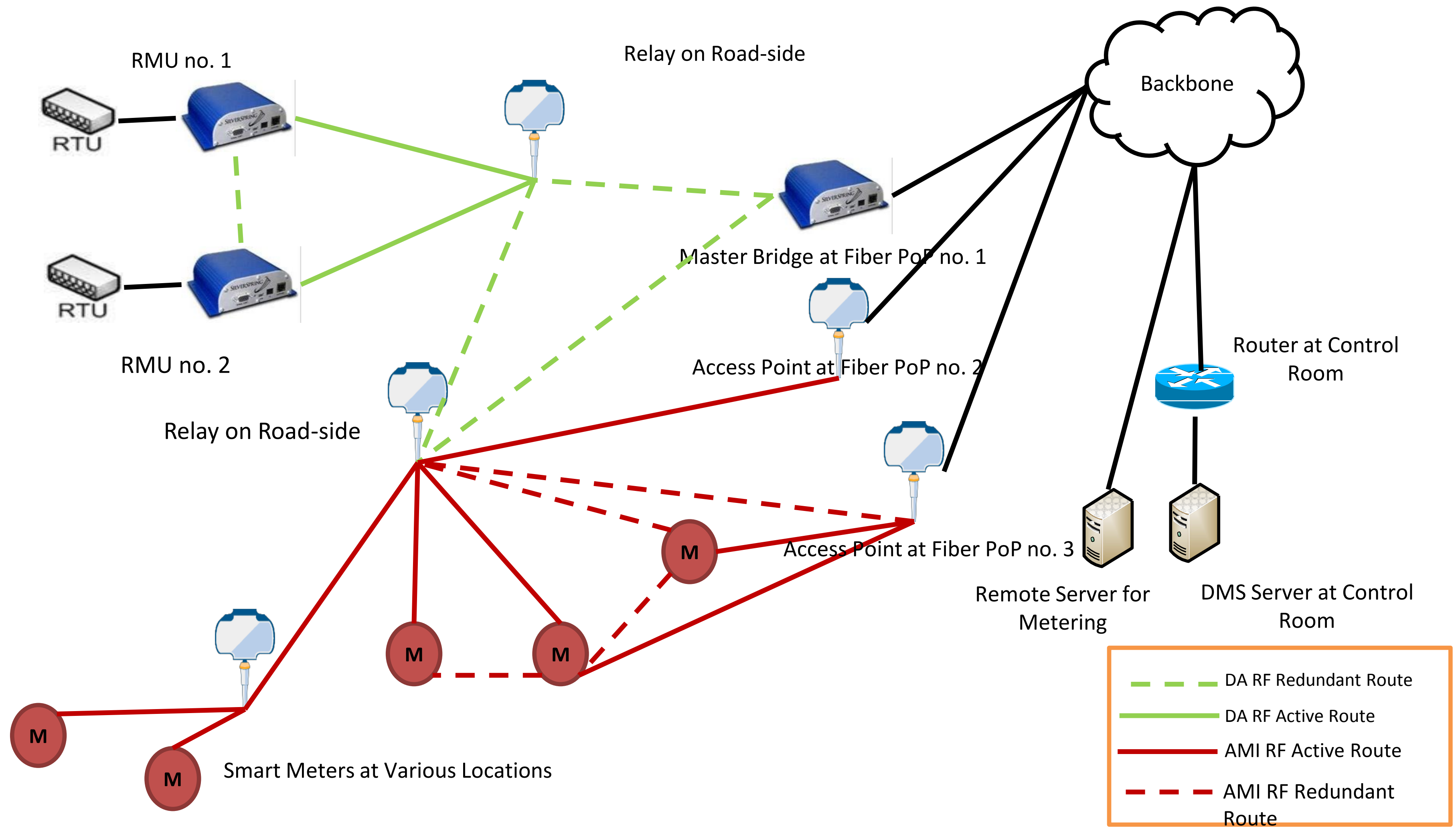


Future Roadmap in Communications

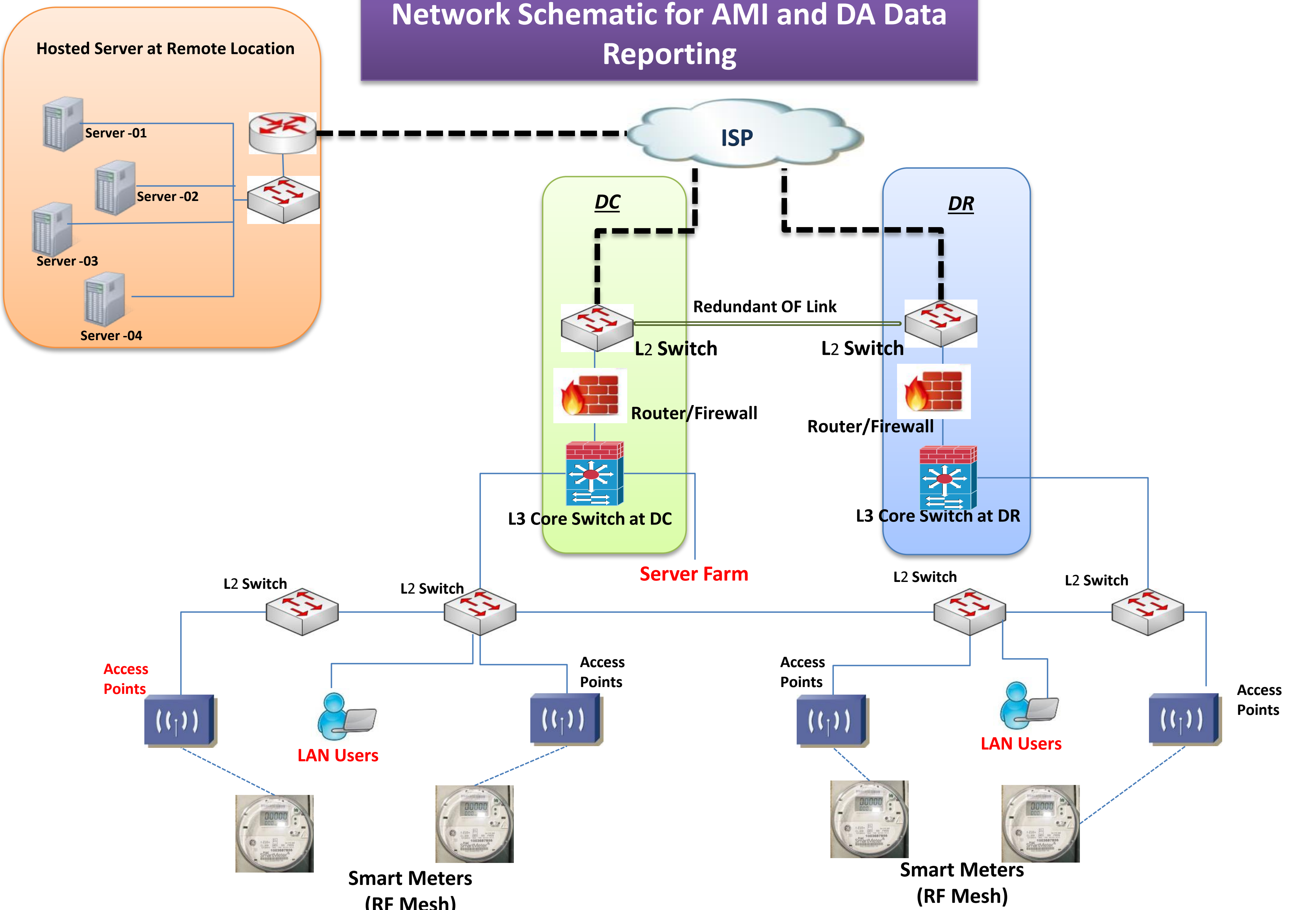
Concept of Smart Metering and Communication Networks involved

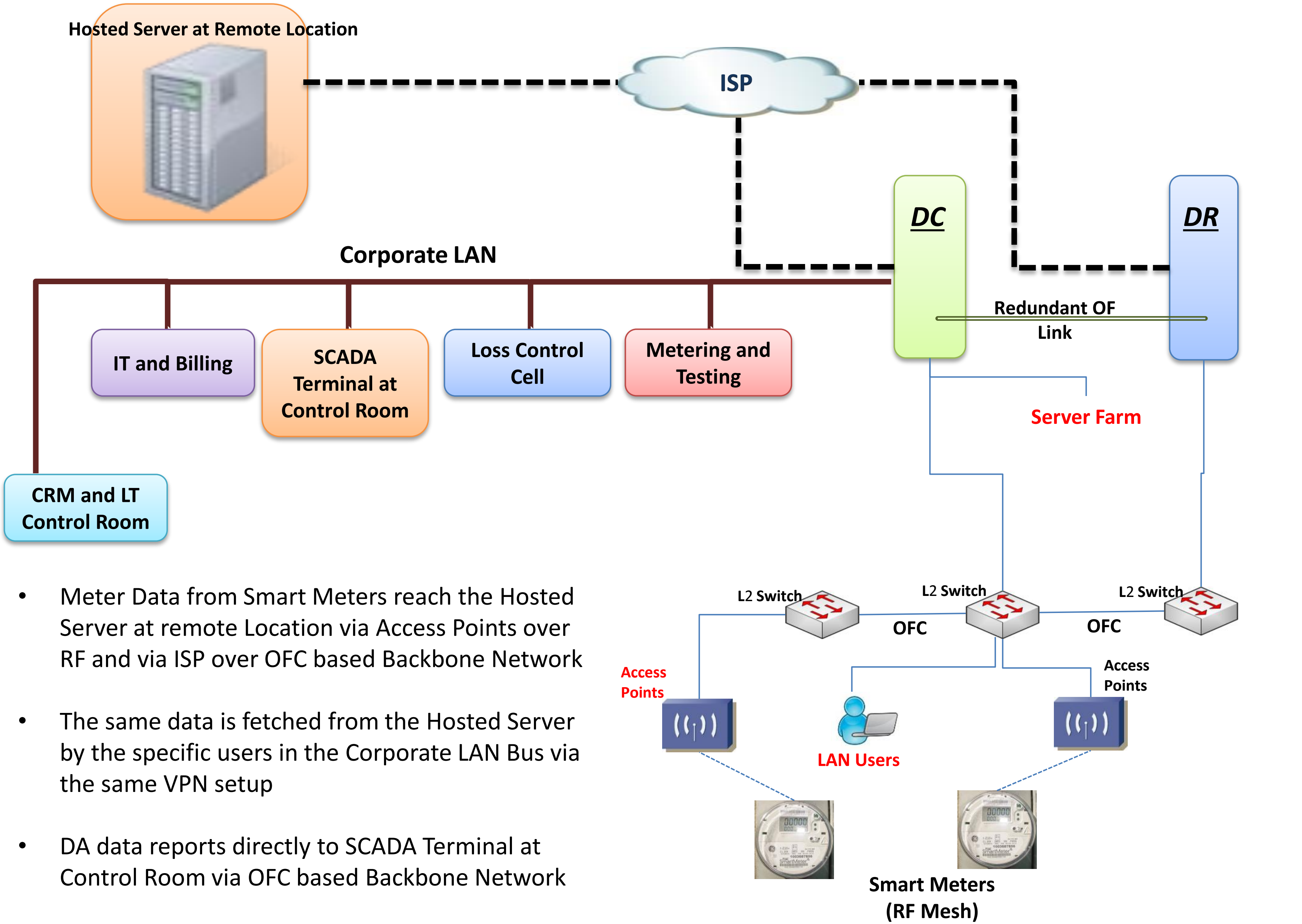


AMI & DA over Wireless Communication Network Schematic



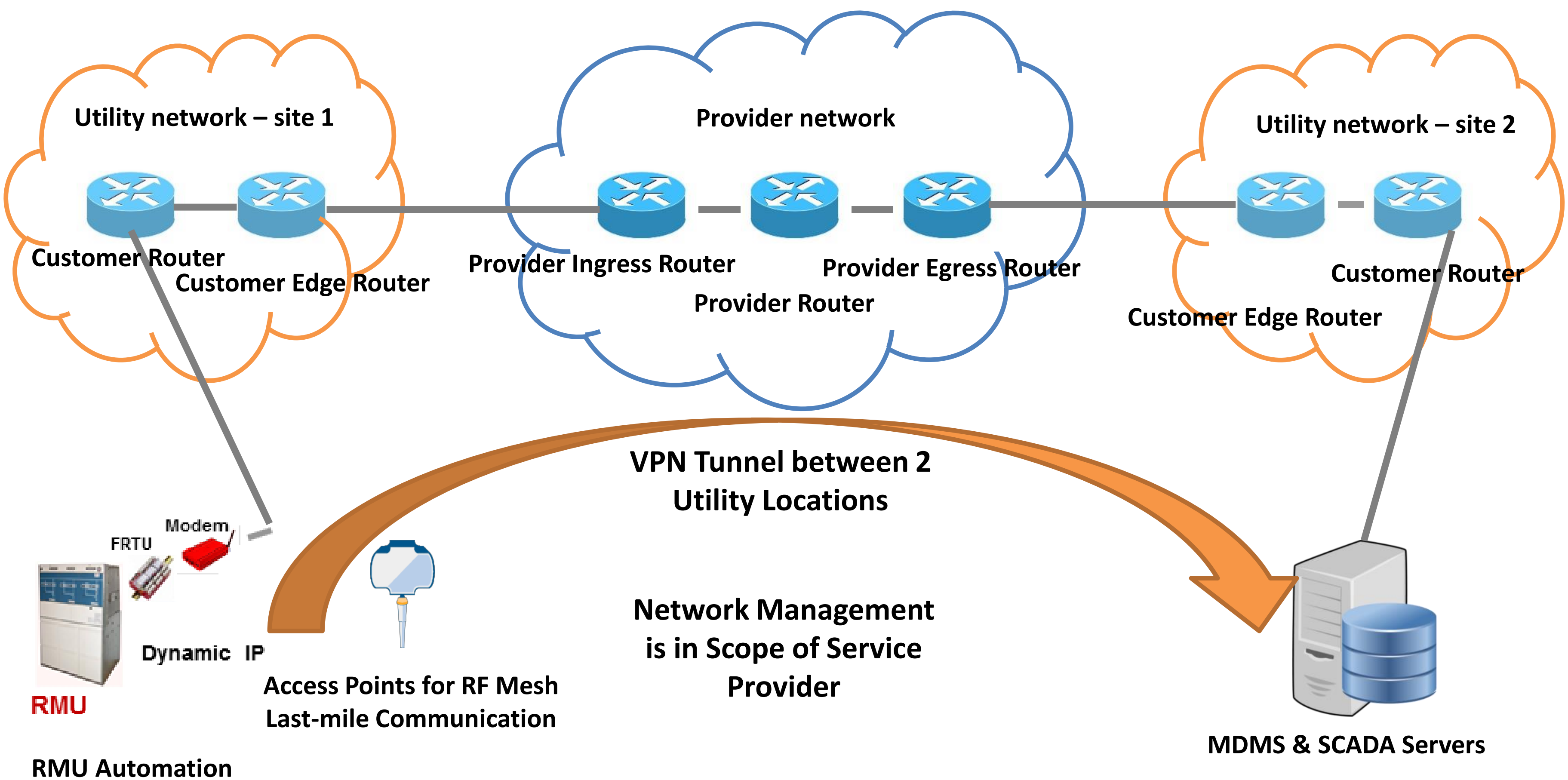
Network Schematic for AMI and DA Data Reporting





- Meter Data from Smart Meters reach the Hosted Server at remote Location via Access Points over RF and via ISP over OFC based Backbone Network
- The same data is fetched from the Hosted Server by the specific users in the Corporate LAN Bus via the same VPN setup
- DA data reports directly to SCADA Terminal at Control Room via OFC based Backbone Network

Multi-Protocol Label Switching (MPLS) as a Backhaul Communication Solution



Power System Protection Schemes

Optical Fiber based Line Differential Protection

RP-Sanjiv Goenka Group

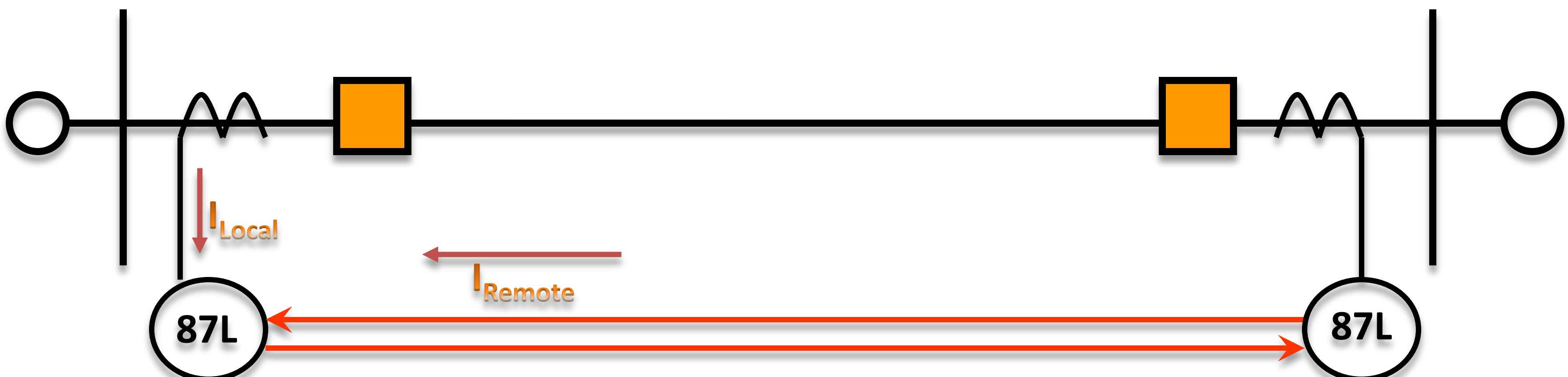
Based on digital communication channels such as optical fibers, SONET network, etc.

Compare current flow in & out line terminals

Easy to discriminate internal & external faults

High dependability – instantaneous trip for all internal faults

High security – no operation for external faults



Optical Fiber based Line Differential Protection

RP - Sanjiv Goenka Group

Differential Function

- Responds to the sum of all the currents of its zone of protection
- Sum equals zero under all events except for internal faults

Features

- Used in Protection of 33 kV, 132 kV and 220 kV Transmission Circuits in CESC
- Mainly optical fiber based
- Protective Relays also capable of Fault recording, and other analysis

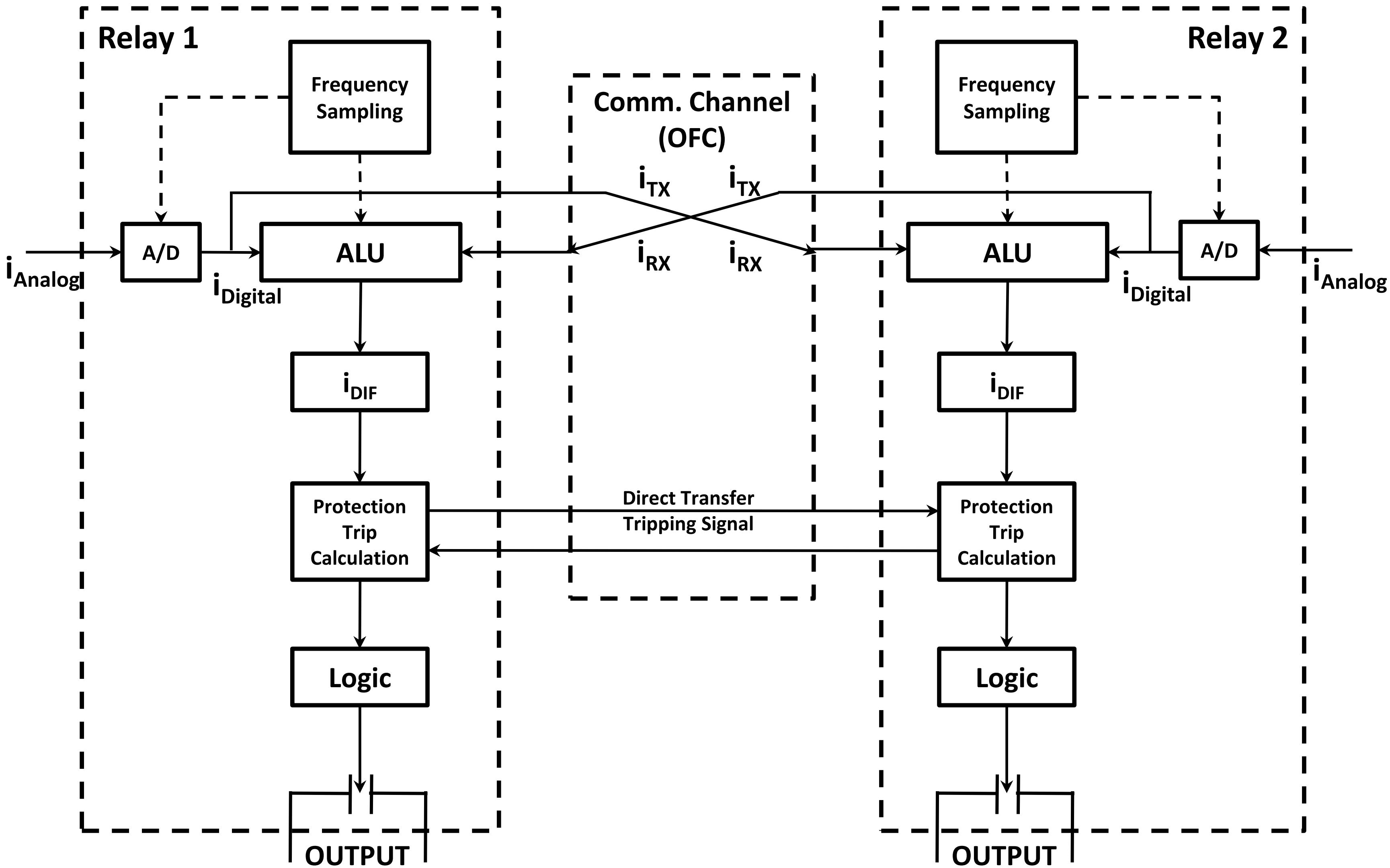
Communication

- Ideally connected in a point-to-point mode
- Can be multiplexed over a network if dedicated channels cannot be spared (IEEE C37.94)
- Ideally 64 kbps channels allotted for Communication
- Maximum Distance Supported – 60 km in 1330 nm Single Mode

Relay Operation

- Numerical Relays capable of sampling analog current input from CTs in zones
- Sampled data transmitted over OFC to remote peer Relay
- Relay receives full set of data from Remote peer Relay
- Operates autonomously
- Issues Direct Transfer Trip signals to Remote peers for tripping of both CBs
- Synchronised via GPS

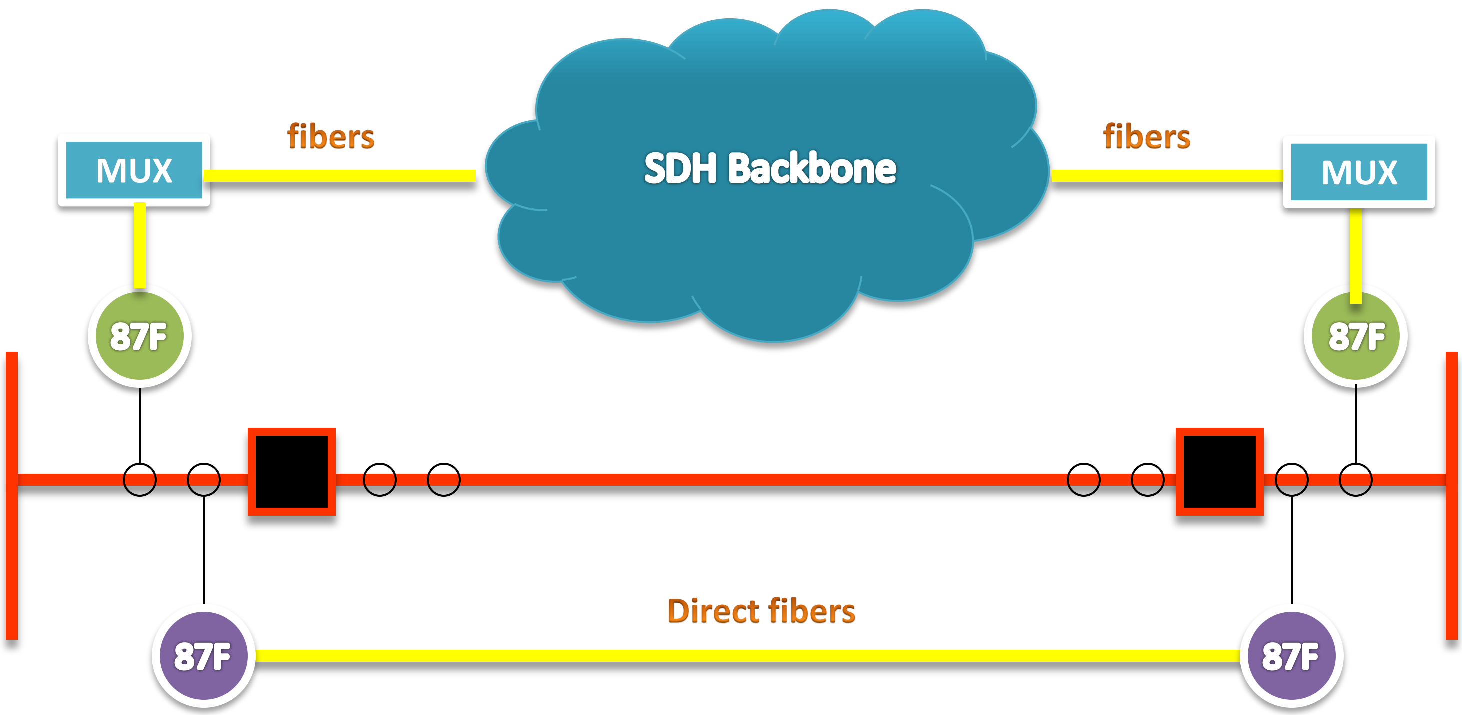
Optical Fiber based Line Differential Protection – Numerical Relay Function



Optical Fiber based Line Differential Protection Scheme

RP - Sanjiv Goenka Group

Ideal usage of Line Differential Protection using Main and Standby Protection Relays over different Communication Routes



Distance Protection

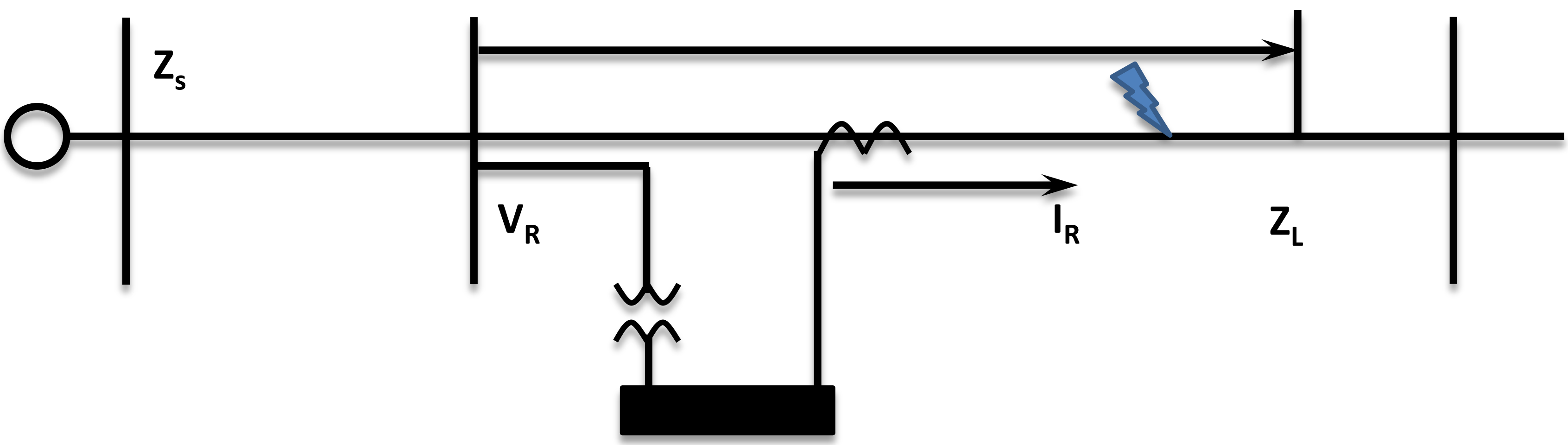
Uses both Current and Voltage to determine if a fault is within the relay's set zone of protection

Settings based on positive and zero sequence transmission line impedance

Measures phase and ground fault loops

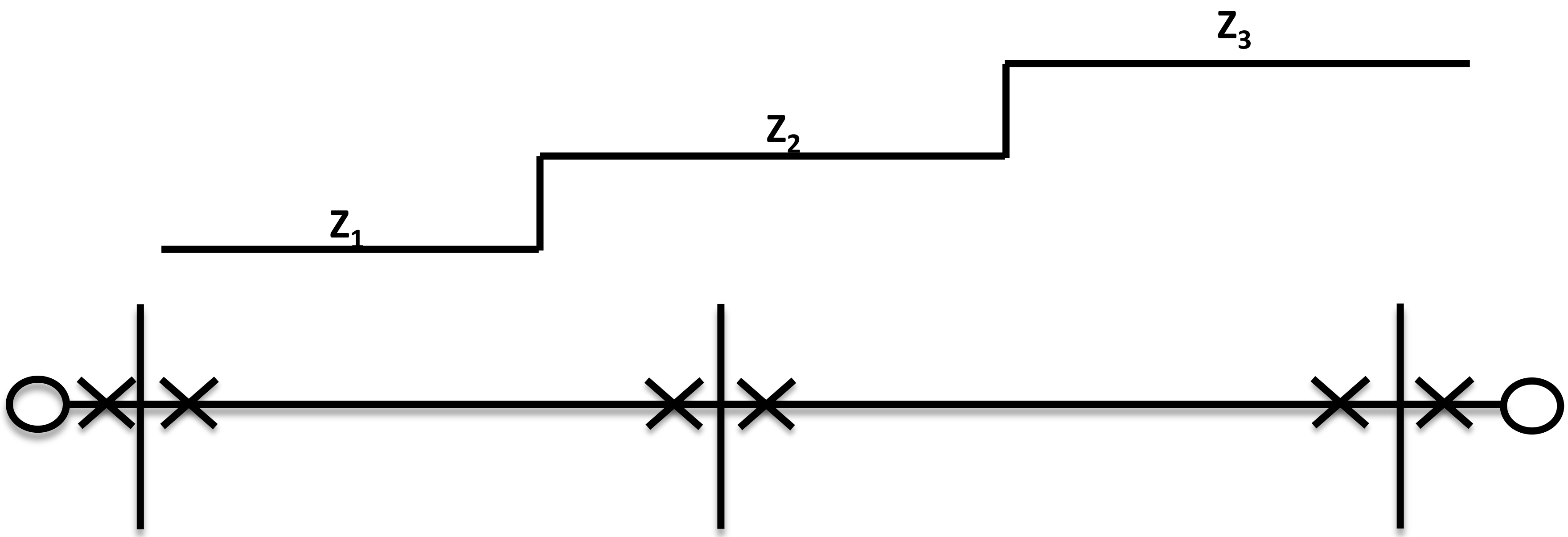
Impedance zone has a fixed impedance reach

Greater instantaneous coverage

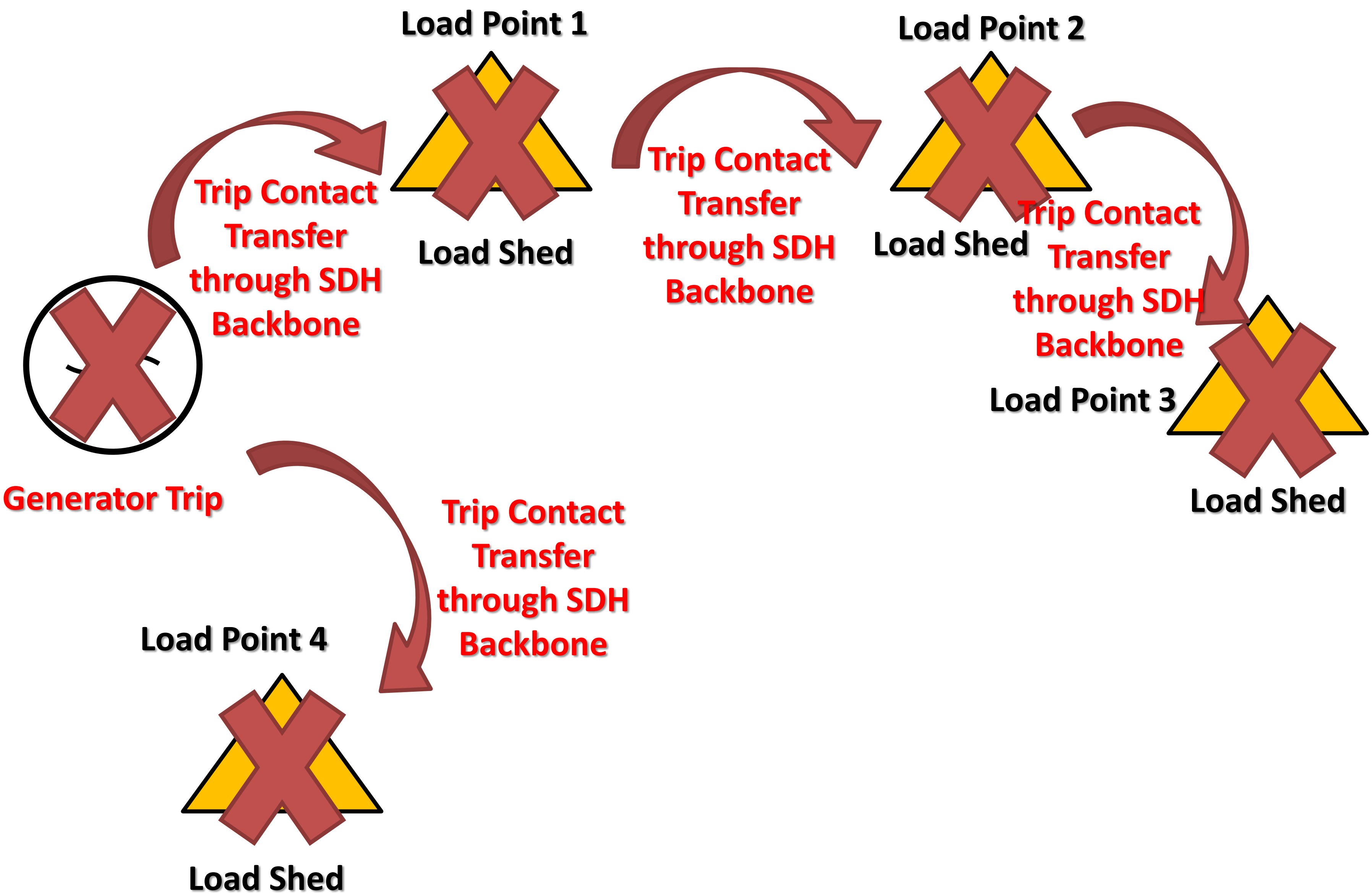


Zones of Distance Protection

Zone 1	80% of protected line
Zone 2	100% of protected line + 20% of shortest adjacent line section or 100% + 50% of transformer impedance
Zone 3	100% of protected line + 100% of longest adjacent line or 100% + 100% of transformer impedance



Lockout Scheme – Contact Transfer




thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
merci
obrigado
bedankt
dziękuję
go raibh maith agat
mochchakkeram
sukriya
kop khun krap
terima kasih
dank je
tapadh leat
спасибо
рахмат
Баярлалаа
mersi
kia ora
barka
welalin
tack
spas
mahalo
faafetai lava
vinaka
спасибі
blagodaram
misaotra
matondo
paldies
grazzi
хвала
asante
manana
obrigada
tenki
murakoze
kiitos
dankie
nanni
nandri
dhanyavad
mauruuru
köszönöm
hvala
gràçie
bayarlalaa
enkosi
dankon
aĉiū
akun
djiere dieuf
tau
дякую
mamnun
chokrane
chnorakaloutioun
gratias ago
gràcies
sulpáy
taiku
sobodi
dĕkuji
sagolun
arigatô
takk
dakujem
trugarez
mèsi
didi madloba
najis tuke
ありがとう
tanemirt
grazie
rahmet
shukriya
mercê
мерси
kam sah hamnida
rahmat
dhanyavadagalu
diolch
ευχαριστώ
তোমাকে ধন্যবাদ
감사합니다
xièxie