A distance relaying protection scheme to supervise Zone

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Abstract

After death examination of certain power outages in the US and Europe has demonstrated that the stage in-zone security zone is one of the essential drivers of power outage in 3 control frameworks. So as to give Zone 3 transfer situational mindfulness and to keep its unwanted stumbling, we propose a non-interloper operator based hand-off supervision separate insurance plan. In the proposed plan, each hand-off which secures the transmission line is related with an operator who can impart and speak with different specialists in the system. In light of the obligations alloted to him, the operator is entirely presumed for him, who is the ace and slave specialist. At whatever point there is a blame in any connection, at that point its related slave operator stays decently to distinguish a mix-up as a genuine mix-up or improbable error with the Master Agent and regardless of whether to travel. Separation Relay Protection Plan is One Time Important Application. In this manner, OPNET reproduction is accomplished for assessment of different correspondence and systems administration topology, which tries to distinguish the topology that meets the necessities of the security plan, the physical media, the systems administration convention of correspondence. The issue of changing the proposed plan to an expansive power network has been delineated as a number programming numerous office area (MFL) issue.

1. Introduction

Power network transmission and sub-transmission lines are normally secured by separation transfer [1]. The principle target of separation transfer security plot is to wipe out an imperfect line from the administration to lessen the bothersome impacts of the fault on the framework. The optional reason for blame confinement is to diminish the measure of burden shed because of transfer prompted dis-relationship of lines. Separation hand-off is neighborhood class (locale 1) hand-off, auxiliary (zone 2) hand-off and named promotion as remote back up (zone 3) hand-off.

So as to diminish the affectability of the separation hand-off for the ordinary mode disappointment, the essential and back-up transfers are physically set in isolated substations, regardless of whether they are observing and securing a similar transmission line. Contrasted with the essential hand-off, the aftereffect of the hand-off line trip is a substantial burden shed remotely. In this way the separation identified with wellbeing is planned in such a way.

That remote back up transfers are not worked until it is totally fundamental, while Zone 1 and Zone 2 hand-off both neglect to clean the deformity.

After an exhaustive investigation of authentic power outages, for example, 1965 Great North-East Blackout, 1977 New York Blackout and 1996 Western Blackout, North American Electric Reliability Council (NERC), it was presumed that the wrong activity of the Zone 3 hand-off is one of the fundamental purposes behind the Cascade-Blackout.

In this way, Horowitz and Phadke inspected the separation handing-off insurance plan to pass judgment on the need of the remote back up transfers yet inferred that the Zone 3 transfers can't be discarded as its end will put the power framework in danger. Ordinarily, it is trusted that the electric framework and its Protective-Tion plans have been planned so that it can work securely through the succession of dependable possibilities without creating consequences of a more extensive field. In any case, because of the startling stacking circumstance, the unfortunate zone 3 transfer outing has added to the falling blackout, which can cause alarming disappointments like power outage. In view of these transitory line stacking and zone 3 transfer miss-trips, there is a calculation master pOS for recreation of falling blackout.

On a NYPP 3000 transport display, 41,053 (24.4%) of 167,752 recreation occasions distinguished appropriate power outage situations in a reenactment test. This uncovered the weakness of zone 3 hand-off for unex-stash stacking conditions and inclinations the requirement for a component to lessen/avert zone 3 miss-trips end.

So as to help the Zone 3 transfers to recognize a genuine blame and an unbelievable blame (because of surprising stacking conditions), in this paper we propose a progressively recognized non-meddling operator based Zone 3 hand-off supervision conspire.

"Help correspondence system and quick registering capacity help field 3 how to separate between a genuine blame and an unreasonable blame (because of unforeseen stacking conditions) and avoiding unfortunate fit field 3 stumbling"

The remaining parts of the paper are composed as pursues: Section 2 Bree the y remove hand-off demonstrates the security plot. The proposed plan is clarified in segment 3. In Section 4, a calculation which deciphers the ace specialist when contrasted with the circumstance of various slave operators. The proposed unique plan in Section 3 has been begun to adjust to vast power frameworks utilizing a MFL issue, which is examined in area 5. In segment 6, the adjustment mod-els identified with the MFL issue have been clarified. To approve the proposed arrangement, we do simu-lions correspondence organize utilizing OPNET and streamlining reenactment utilizing IBM ILOG CPLEX, which is clarified in segment 7. Area 8 contrasts the proposed arrangement and the line security conspire.

2. Distance relaying protection scheme

The regular separation works based on guideline of transfer impedance proportion, which is the proportion of the greatness of the me-flooded voltage to the present size. To figure the mistake in the detecting gadgets, to ascertain the vulnerability out there setting of the transfer and to guarantee that there is no vulnerable side, numerous zones of security (zone 1 and zone 2) on every transmission line em-ployed Are. Within the sight of an error if the breaker related with Zone 1 or Zone 2 hand-off does not trip (Current Transformer, Voltage Transformer Due to disappointment in voltage transformer, hand-off or breaker), the

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blame line can not be isolated from the framework. To expel this circumstance, a reinforcement hand-off or zone 3 hand-off is set in a remote substation. Hence there are three unique zones of security for example zone 1, zone 2 or zone 3 transfer. It is now pre-clear that the remote back-up transfer is favored for nearby reinforcement hand-off in light of the fact that later the essential hand-off (zone 1)

Correspondingly, the settings of R21 for Zone 1, Zone 2 and Zone 3 can be accomplished by changing Z12 with Z1 in the above conditions. Here is the impedance of the transmission line associated between Zxy transport x and transport y. Zone 1 hand-off works promptly, for example inside 1-2 cycles (16-32ms). Deferral in the coordination of the 2030 cycle (300-500 ms) is permitted before the zone 2 hand-off is worked. Zone 3 hand-off or remote back-up hand-off is permitted to work with coordination postponement of 1S Coordination delay not just gives selectivity in isolating a defective segment, yet in addition guarantees the unwavering quality of the activity of the remote security plot [8]. A point by point clarification of the zones of assurance is past the extent of this letter. Intrigued perusers are alluded.

1. Proposed scheme

In this segment, the Agent Based Zone 3 Relay Supervision Scheme has been clarified in detail. The primary distinction between our arrangement and other specialist based hand-off plans (like [10,11]) is that our operators are non-interferers, that is, they don't take the social practical ity, however just in the basic leadership and Help hand-off whether to travel Transfer Protection Engineers don't care for the possibility of intrusive specialists, so we got a kick out of the chance to utilize non-gatecrasher operators in our zone 3 supervision arrangement. One deformity in the single transmission line is felt by a few transfers under the security of various regions (Zone 1, Zone 2 and Zone 3). For instance, in Figure 1, a blame in the transmission line associated between transport 1 and transport 2 can be acknowledged by R12, R21, R43, R31, R31, R52, R65, R72, R91 and R85 In our arrangement, each transfer is related with a specialist who can speak with different operators in the system. At whatever point a transfer feels any oversight in the transmission line ensured by it, its subsidiary specialist records it and speaks with different operators securing a similar transmission line in the system, if the supposed mix-up is a genuine slip-up or false It's a slip-up.

On the off chance that the majority of the other hand-off defenders of a similar transmission line are additionally absconded, at that point they can promote the hand-off identified with specialist travel, arranging it as a flawed condition. Then again, in the event that there is no imperfection in the majority of the other transfer, at that point ordering it as a deformity free condition, the operator encourages not to venture to every part of the hand-off. This is on the grounds that the circumstance of impermanent stacking can cause a blame in the retranslation and the hand-off does not require it for movement. It is conceivable that a blame in the single transmission line from the two sides of the transmission line can be recognized somewhere around six transfers for example Zone 1, Zone 2 and Zone 3 Therefore, to group a delicate error as a genuine mix-up or a farfetched oversight, the specialist must speak with in any event the ify ve operator.

Reaction times. In the event that the absolute reaction time is higher than the transfer disappointment given in Section 2, the specialist based hand-off supervision-Sion plan does not satisfy the expected reason. In this manner, to decrease response time, or-der, operators are progressively recognized as slave specialists and ace specialists.

A slave specialist transfer records the status of the blame of his hand-off hand-off and reports it to the ace operator at the rate of multiple times/s. The Master Agent is invested with high benefits and obligations relations. Anytime of time, a Master Agent has the mistake status-infor-announcing everything being equal. So at whatever point the transfer feels a mix-up, at that point its related slave hand-off specialist records it and grills the ace agent,The Master Agent looks at (utilizing Algorithm in Section 4) ensures the state of the slave hand-off operator's blame, with the status of the other slave specialist's blame. A similar transmission line orders the blame as a genuine slip-up or an unreasonable slip-up and acknowledges the Quirid Slave transfer operator to venture out or not to go outside the administration, separately.

The whole procedure is to be cleared inside the clearing time of the particular hand-off for example typically 1 zone for zone 3 transfer, 300 ms for zone 2 hand-off and practically quick for zone 1 hand-off. Outfitted with the present condition of craftsmanship correspondence and systems administration - Zone 1 and zone 2 address diverse issues for meeting time prerequisites, however the deficiency of zone 3 hand-off time can be finished. Subsequently, this Paper Zone 3 transfer limits its investigation for supervision.But despite everything we need specialists at all transfers ie Zone 1, Zone 2 and Zone 3, since all different transfers (Zone 1 and Zone 2) are named a right oversight or A to ZONE 3-light blame.) Should know the status of the mix-up. False conviction To call the proposed plan, the operator based separation is checking the transfer plan zone 3 hand-off.

2. On the off chance that this blame is identified just by the Zone 3 transfers, since other re-lays (Zone 1 and Zone 2) in the related hand-off set don't distinguish this blame, it is seen as an incredible blame. Likewise, in our plan, if the Zone

3 transfer does not get any exhortation from the ace operator inside 1 s, it trips.

4. Algorithm

At the point when questioned by a Zone 3 slave transfer operator, so as to think about the blame status of various transfers securing a transmission line, an ace specialist must know early which set of transfers are ace tecting a transmission line. The calculation for making expert operator examination rules is as per the following:

(a) Read control framework organize information file. We have utilized IEEE standard information files.

(b) Store transport numbers, transmission lines, transformers connected between transports, obstruction and reactance of the transmission lines from IEEE information files. As clarified above (c) Convert the given power framework organize into a diagram G(V, E, R). Where V is the arrangement of n vertices and every vertex is signified as V[i]. Here I = 1, 2,..., n. E is the arrangement of m (c)Depth first look (DFS) is a notable and generally utilized seeking calculation in chart hypothesis. From Fig. 1 clearly the DFS can be connected to find the arrangement of transfers ensuring a transmission line. For a hand-off Rxy.

5. Applying Zone 3 supervisory scheme to a large bus system

As appeared in Figure 2, just a single ace operator (Section 7 OPNET reenactment) on Bus 6 for a little transport framework (IEEE 14) can deal with inquiries from all Zone 3 slaves on the grounds that there was delay in round outing correspondence Is there a slave specialist and not exactly an ace operator in such a little transport framework. On account of a pragmatic power framework arrange, which are topographically across the board around long separations (miles away) and there are substantial quantities of transports (> 1000)A single ace operator can not be sufficient to serve all Zone 3. Slave specialist line ries The explanation behind this is round outing postponement might be more than 1 s in length remove between ace operator and one zone 3 slave specialist hand-off, which readies the Zone 3 Relay Supervision Scheme to unfreeze - with the assistance of Zone 3 Relays to group faces as an error. A genuine misstep or a wrong mix-up happened.Therefore, to oblige a substantial transport framework, or field 3 hand-off supervision plan, more than one ace operator is required in the der and the spot of these ace specialists ought to be with the end goal that any region gathered together to 3 slave specialist transfers Delay in movement correspondence And something like one ace operator ought to be under 1 S. In this way, the issue close by can be depicted as pursues:

When a slave specialist hand-off is chosen as an ace operator, it is as per the following: Additional obligations portrayed in segment 3 were agreed upon. It is referenced that an imperfection in the single transmission line can be distinguished by a few transfers under the assurance of various regions. Aside from this, it is the contrary that I can feel an oversight in more than one transmission line under various zones of security in a hand-off.

(c) Convert the given power framework organize into a diagram G(V, E, R). Where V is the arrangement of n vertices and every vertex is signified as V[i]. Here I = 1, 2,..., n. E is the arrangement of m edges and each edge is meant as E[j], j = 1, 2,.. . , m. R is the arrangement of 2m transfers. Every vertex speaks to a power framework transport and each edge speaks to a transmission line or a transmis-sion line associated between transports. EV is the arrangement of edges associated with a vertex 'V'. Where each edge associated with a vertex is meant as EV[l], l = 1, 2,.. . , k. Rxy speaks to a transfer

slave specialist - all slave operators give an ace operator to reduce the greatest number of assignments on the transfer.

The maximum number of master agents that a slave agent relay has to report, is minimized. Eqs. (9) - (11) are similar to the one. (5) - a very important hurdle which states that a relay-set can only be assigned to a master agent if the round trip communication between the master agent and all the slave agent is in the relay-set. Clearing time (tm) less than zone 3 relay

Toward the finish of second stage, the quantity of Master Agent and their place is known and we likewise realize that a slave specialist is

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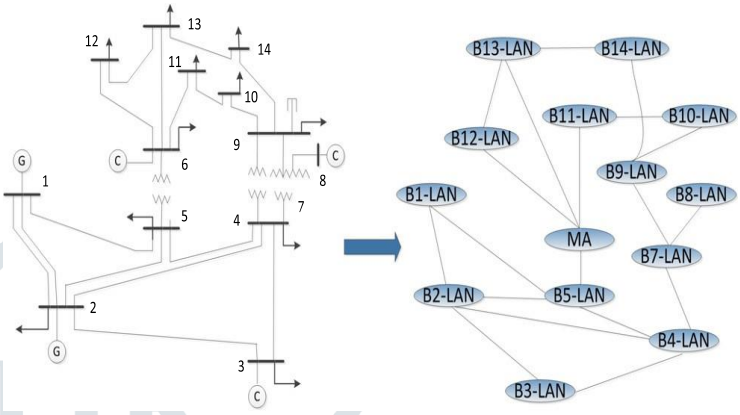

Fig. 2. Communication architecture (Ethernet WAN) similar to power system network topology connecting LAN's at different substations.

ber of master In this segment, the issue depicted in Section 5 is outlined as MFL issue. MFL is a whole number straight programming issue that settles numerical demonstrating and sol naming - answers for issues identifying with ideal position of offices to lessen transportation costs, time of movement for clients and so forth. The ace specialist in taking care of issues is the operator. Shoppers are considered as offices and slaves specialists. Let be N 'be the quantity of transports and be M' a power sys-The quantity of transmission lines in the sanctuary arrange. As a Master Agent is relied upon to keep on the transport, the quantity of potential Master Agent areas is additionally 'N'. The quantity of hand-off set is equivalent to the quantity of transmission lines in rel N 'organize. We have fathomed the advancement calculation in three stages to rearrange the procedure.. On the off chance that we had arranged the issue as a multi-criteria advancement issue and settled it in a solitary stage, at that point we would presumably get an increasingly ideal position, yet unraveling multi-criteria streamlining is of more consistence and Will not be on the scale for the framework. 3000 transports We utilize the accompanying documentation to clarify the customization display

In Step I, each transfer set is appointed to an ace operator. Transfer Set Assignment does not give an arrangement NAL arrangement on the grounds that as a general rule the slave operator depends in the hand-off set answer to the ace specialist yet not hand-off set. So in the second stage, we appoint to each

answering to Riley X 'Ace Agent Y. Aside from this dimension, as appeared in Fig. The quantity of slave specialists can likewise be found by answering to many ace operators. As the subsequent stage in Phase III we diminish the all out number of slave operators who speak with many Master Agents, though the all out number of Master Agents is kept up like Phase II.

In basic terms the contrast ence between stage II and stage III is that, toward the finish of stage II the situation of ace operators (offices) can be with the end goal that slave specialists (clients) A, B, C and D are answering to 1, 2, 3 and 4 num-ber of ace operators individually for

example all out slave specialist to ace operator blame status information exchanges is 10 though the stage III may find an area for the ace specialists with the end goal that the slave specialists A, B, C and D could be answering to 2, 1, 3, 2 number of ace specialists individually for example complete slave specialist to ace operator blame status information exchanges is 8. It is previously mentioned that each slave specialist reports blame status multiple times/s to an ace operator. In this manner diminishing the quantity of information exchanges from 10 to 8 for example 2 can outcome in a decrease of 60 (2 30) information bundle exchanges/s. For bigger transport sys-tems if the quantity of such diminished information exchanges from stage II to stage III is of the request of hundreds then a significant decrease in parcel information exchange can be accomplished. In this way, stage III endeavors to limit the absolute number of slave specialist to ace operator bundle information moves and helps in efficient correspondence arrange structure.

In order to evaluate the end-to-end latencies between the mas- ter agent and Zone 3 slave agent relays, OPNET modeler network- ing simulations are performed. As a part of our simulations we explored different network topologies, physical media of commu- nication, network protocols, and link bandwidths to find out the best possible combination. We performed experiments with three different communication network topologies for the IEEE-39 bus system. In the Type I network, the network topology is assumed to be same as that of the power system topology. In this model, each bus in the power system has a corresponding communication node (router or host) and parallel to each transmission line there is a communication link. According to the optimization algorithm discussed in Section 5, the best possible location for the master agent of IEEE-14 bus system is bus 1. The optimization related sim- ulations are discussed in next subsection. We allocate slave agents to buses which monitor the status of relays in their vicinity. In the Type II network, we consider an alternative topology (star topol- ogy) in which each bus agent has a dedicated communication link to the master agent. In the Type III network, we examine a more practical network configuration which is shown in Fig. 2. We as- sume that a distance protection relay has an agent associated with it that can communicate directly with the master agent. Slave agent relays near a bus/substation are connected in a local area network (LAN) which uses Ethernet as a link layer protocol. Slave agent relays can send messages from one LAN to the other LAN or master agent via routers. The communication links are similar to the Type I network.

The simulations parameters of interest are as shown in Table 1. In Table 2, the maximum response time from a Zone 3 slave agent to the master agent is given for each of the three different network configurations described above. All the network configurations sat- isfy the Zone 3 relay fault clearing time of 1 s. But for the simula- tion of large power system networks, we consider Type III network configuration as it appears to be practical for the relays at a substa- tion (bus) to be connected in a LAN and communicate via a router with the external world. It is well known that PLC is a harsh med- ium and data transfer through it can create a lot of problems [12]. Compared to copper wires, optical fibers are less expensive, expe- rience lower signal degradation and require lower number of repeaters [13]. Therefore we prefer to use optical fiber for the remainder of the OPNET simulations.

7.1. IBM ILOG CPLEX simulations

The optimization models presented in Section 6 are tested using five (IEEE 9, IEEE 14, IEEE 30, IEEE 57 and IEEE 118) different bus systems as inputs. An Ethernet wide area network (WAN) as shown in Fig. 2 is designed for each of the above mentioned IEEE bus sys- tems and OPNET simulations are performed to collect round trip communication delays. The data collected from OPNET simula- tions, which is arranged as a N N matrix is as shown in Table 3. Here N is the number of buses in the power system network.

The results obtained from CPLEX simulations are as shown in In the distance relaying protection scheme, the Zone 3 fault clearing time is 1 s i.e. for CPLEX simulations the parameter t_m used in optimization models has to be set to 1 s. We have used smaller bus systems (<120 buses) as test inputs. The maximum round trip delay for IEEE 118 bus system (largest test input) is 279 ms which is less than 1 s. If we set t_m = 1 s, for all the test inputs the simulation results indicate that the Number of Master Agents (NMAs) required is one. Therefore just for the purpose of illustration the value of t_m is reduced from 1000 ms to 200 ms. Off course, if you have access to larger power system network consisting of thousands of buses t_m can be to 1 s. As shown in Table 4, with t_m = 200 ms, IEEE 118 bus system requires 4 master agents, IEEE 57 bus system requires 2 master agents whereas a single master agent is sufficient for IEEE 9, 14 and 30 bus systems. At the end of phase I, the location of mas- ter agents for IEEE 57 bus system is at buses 38 and 49. The total number of slave agent to master agent data transfers at the end of phase II is 678/s with master agent locations 31 and 38 whereas at the end of phase III the number of slave agent to master agent data transfers is reduced to 426/s and the master agent locations are shifted to 28 and 38. Therefore the advantage of using the phase III is obvious, which resulted in a significant (252 data transfers/s i.e. 30%) reduction of slave agent to master agent data reportings while the number of master agents is maintained same as that of the phase II. Thus the optimized locations for the master agents are Lo- cal Area Network (LAN) at buses/substations 28 and 38. Similarly for IEEE 118 bus system the reduction in the number of slave agent to master agent data transfers from phase II to phase III is 510 which is approximately 20%.

MAL is the Master Agent Location. t_{ij} is the round trip commun
tion delay between the slave agent at location j and the master agent at location i. IBM ILOG CPLEX is a tool for modeling and sim- ulating optimization based analytical decision support applications [14]. The data collected from the OPNET simulations is modified in order to generate a suitable input for the CPLEX simulations. Using the algorithm in Section 4, relay-sets are generated for all the transmission lines in a given power system network. Actually a relay-set is a set of sets. The number of individual sub-sets in a re- lay-set is equal to the number of transmission lines. Each sub-set indicates the set of relays protecting a transmission line under dif- ferent zones. Also the size of the each sub-set depends on the power grid topology i.e. the number of relays that can sense fault in a transmission line depends on the power system network topology. The relay-set information and the communication round trip delays are given as input to CPLEX. Optimization models de- scribed in Section 6 are programmed in CPLEX using the OPL mod- eling language. The OPNET networking simulation files and CPLEX optimization models

can be found at www.filebox.vt.edu/users/ gshra09/facility.zip.

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