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Cost Optimization of Dynamic Service Reliability: A Case Study of Demand Fulfillment on Enterprise

Mudjahidin Mudjahidin[1]* **Joko Lianto Buliali[2]** **Muhammad Nur Yuniarto[3]**

[1]*Information System Department, Institut Teknologi Sepuluh Nopember, 60111, Indonesia*
[2]*Informatics Department, Institut Teknologi Sepuluh Nopember, 60111, Indonesia*
[3]*Center of Excellence in Automotive and Control System, Institut Teknologi Sepuluh Nopember, 60111, Indonesia*
* Corresponding author's Email: mudjahidin@is.its.ac.id

Abstract: As a system, private industrial network (PIN) could be computed its service reliability for a specific duration time where the service reliability has two cost components (reliability costs and unreliability cost) which opposite and non-linear. Furthermore, in the PIN, service reliability could have the effect to demand, and the demand also influenced by the external factor. For this reason, we propose a computation of service reliability and find the optimized service time, which can minimize the total reliability cost and unreliability cost for a specific duration time. Furthermore, in this proposed model, reliability and external have the effect to demand. Based on the case study, we implement and simulate the model with random service time, and, as an improvement, we simulate again the model by substitute random service time with optimized service time. The simulation results show the different dynamic value of demand, reliability, average reliability, reliability cost and unreliability cost, where the results from the simulation with optimized service time are mostly better than the simulation with random service time. The total reliability cost of service does not all decrease, but the overall total reliability cost decreases, that is $ 3,409,315 became $ 313,595.

Keywords: Service reliability, System dynamics model, Demand, Optimized service time, Reliability cost, Unreliability cost.

1. Introduction

System reliability might have two types of cost, namely reliability cost (such as the cost to improve maintenance, the cost to improve quality, the inventory cost of component [1-3]) and unreliability cost (such as the cost of reliability decrease, damage cost, loss sales [4-6]). Commonly, both costs could be non-linear and opposite each other [7, 8]. This condition causes the opportunity cost when the reliability of a system is high, it causes reliability cost increase, and unreliability cost decrease and another hand, if it is low, reliability costs decrease and unreliability cost increase.

Furthermore, in a system, reliability might have a relationship with productivity, effectiveness, awareness, design [9-12]. As well, in a dynamic system, reliability might also have a relationship with efficiency, repair, and the degradation process [13-15].

Based on the costs of system reliability and the reliability relationship in a system as described above, raised an issue that is how to find a value of service time which can minimize the total reliability cost and unreliability cost and how effect reliability to performance or other variables in a system. Related to the optimization of the system reliability, previously, a technique for solving a family of multi-state systems (MSS) reliability optimization problems presented to minimal cost of investment [16]. The study is followed using a multi-processor genetic algorithm in order to solve the structural optimization problem [17] and solving multiple objective multi-state reliability optimization design (maximization of system availability minimization of costs) developed by GA [18]. Algorithm

Combination of ant colony optimization and strength Pareto fitness assignment procedure to solve both continuous function and combinatorial optimization problems in reliability engineering [19]. Next, GA used to optimize the electrical network reliability [20] and solving multi-objective reliability optimization using particle swarm [21]. Therefore, in this article, we propose a computation of service reliability and find the optimized service time, which can minimize the total reliability cost and unreliability cost for a specific duration time. Furthermore, in this proposed model, reliability and external have the effect to demand.

For the purpose, we develop a system dynamics model which consists of many variables forming the feedback to accommodate the reliability effect to demand. In the model, the demand variable also affected by the external factor. In this article, the name given to the model is cost optimization of dynamically service reliability (CODSR).

To prove that the model can be used to solve the issue mentioned, in this article, we implement CODSR model on the case study of the enterprise which has IT product demand, IT service demand, and warranty demand for both (as a mandatory after delivery of the product and service). In this implementation, we simulate CODSR model with two scenarios. The first, simulation use the service time generating by the exponential number generator, and the second, as an improvement scenario, simulation use the fixed service time resulting from the optimization value of reliability cost and unreliability cost. Next, at the end of this article, we compare and analyze the result of the two scenarios.

We organize the remainder article as follows. Section 2 presents the model of cost optimization of dynamically service reliability that consists of reliability and average reliability of dynamic service (2.1), cost of reliability and unreliability (2.2), and cost optimization method (2.3). Section 3 provides the case study that consists of the CODSR model implementation (3.1), model testing (Section 3.2), and scenario simulation (3.3). Section 4 presents the result that consists of scenario simulation 1 (4.1), cost optimization (4.2), and scenario simulation 2 (4.3). Finally, the conclusion is presented in section 6.

2. Cost optimization of dynamically service reliability

In this section, we present CODSR as a system dynamics model that can be used to compute the dynamic service reliability and find the optimized value of total reliability cost consisting of reliability cost and unreliability cost on a causal loop diagram (CLD) as shown in Fig. 1. The CODSR model that we proposed is the causal loop diagram divided into two parts. The first part of the model (black line) is used to compute the reliability and average reliability of dynamic service in an enterprise. In this model, the demand is affected by the external factor. Next, the second part of the model (blue line) is used to compute the total reliability cost for individual service and all service. Therefore, in the next section, we describe how to compute each variable in two parts of CODSR model.

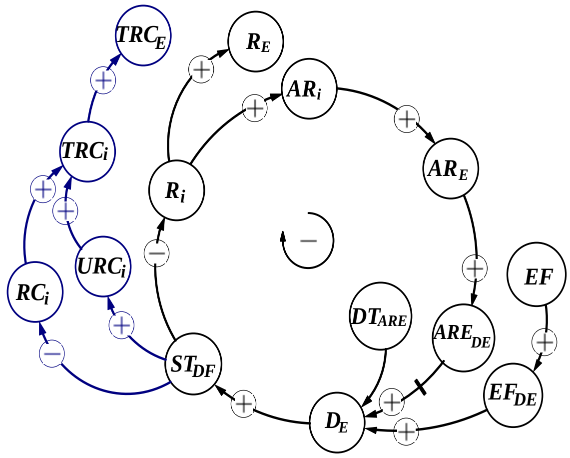


Figure. 1 CLD of CODSR model with the external factor (EF) and average reliability effect (ARE_{DE}) to demand (D_E)

2.1 Reliability and average reliability of dynamic service

Based on the first part of Fig. 1 (black line), the reliability and average reliability of dynamic service in the first part of CODSR model form feedback with the negative loop beginning at the demands of enterprise (D_E). D_E consists of several demands, where the amount of each demand resulted by a specific distribution or a fixed value. Each demand has dimensions of service reliability that set by an enterprise (DSR_E). D_E is affected by the external factor (EF) through the value effect of an external factor against it (EF_{DE}) as studied by [22-25] that resulted by a lookup function. EF has a value between 0 to 1 depending on the external factor condition (such as economic condition, the power of competition, and the effect of technological development). Next, EF_{DE} is a value resulting from the lookup function caused by EF.

Firstly, we consider EF and EF_{DE} as x_i and y_i, respectively. The equation of $EF$and EF_{DE} as $x_i$and y_i is described as follows.

$$y_i(x_i; 0 \le x_i \le 1) = \begin{cases} 0, \text{if } 0 \le EF \le x_1 \\ y_1, \text{if } x_1 < EF \le x_2 \\ y_2, \text{if } x_2 < EF \le x_3 \\ . \\ . \\ y_n, \text{if } x_n < EF \le x_{n+1} \end{cases} \quad (1)$$

Where, if $D_E > 0$ then service time of demand fulfilment (ST_{DF}) is generated by a random number of current distribution or a fixed time. The random number of ST_{DF} that used to compute CODSR could have Exponential, Poisson, Gamma, or Weibull distribution as described by [9, 26, 27].

We compute the reliability of individual service based on DSR_E (R_i) which has specific reliability distribution function $f(x)$ with service time of demand fulfillment for each reliability dimension (ST_{DF}) using equation as follows.

$$R_i = f(x) \quad (2)$$

Next, we compute the reliability of all services (R_E) as the parallel arrangement of R_i using equation as follows.

$$R_E = 1 - \prod(1 - R_i) \quad (3)$$

Furthermore, in CODSR, we compute the average reliability of individual service (AR_i) every interval time for computing average reliability (IT_{AR})using equation as follows.

$$AR_i = \frac{A_R}{N_R} \text{ for every } IT_{AR} \quad (4)$$

Where, A_R and R_R are the accumulated reliable R_i over a specific interval time and Number of reliable R_i over one specific of interval time, respectively. Next, the average reliability of all services (AR_E) computed using equation as follows.

$$AR_E = \frac{AAR_I}{N_{AR}} \text{ for every } IT_{AR} \quad (5)$$

Where, AAR_I and N_{AR} are the accumulated of capable AR_i over a specific of interval time and the number of capable AR_i over a specific of interval time, respectively.

AR_E affect D_E through the value of average reliability effects against it (ARE_{DE}) so that CODSR model forms a feedback loop. ARE_{DE} is a value resulted from the lookup function caused by AR_E (Eq. (5)) with the delay time of ARE_{DE} (DT_{ARE}). As a lookup function, we consider AR_E as x_i that have a value between 0 and 1, and ARE_{DE} as y_i [28]. Therefore, this lookup function described as follows.

$$y_{D_i}(x_i; 0 \le x_i \le 1) = \begin{cases} 0, \text{if } 0 \le AR_E \le x_1 \\ y_1, \text{if } x_1 < AR_E \le x_2 \\ y_2, \text{if } x_2 < AR_E \le x_3 \\ . \\ . \\ y_n, \text{if } x_n < AR_E \le x_{n+1} \end{cases} \quad (6)$$

All relationship among variables in the first part of CODSR model (see Fig. 1) is positive (+), except the ties between, ST_{DF} and R_i are negative (-). Hence, the relationship among variables in the first part of CODSR model has the negative feedback, where the relationship of among variables in system dynamics model is studied by [29-33].

2.2 Cost of reliability and unreliability

In the second part of Fig. 1, the reliability cost of each $DSR_E(RC_i)$ and the unreliability cost of each DSR_E (URC_i) presented in the second part of CODSR model (see Fig. 1 with blue line). Where, RC_i and URC_i are depending on ST_{DF} [7, 8, 34, 45] and resulted from the lookup function. Next, ST_{DF} considered as x_i, and RC_I and URC_I are regarded as y_i. So, the lookup functions are computed as follows.

$$y_i(x_i; \min ST_{DF} \le x_i \le \max ST_{DF}) = \begin{cases} y_1, \text{if } x_1 \le ST_{DF} \le x_2 \\ y_2, \text{if } x_2 \le ST_{DF} \le x_3 \\ . \\ . \\ y_n, \text{if } x_n \le ST_i \le x_{n+1} \end{cases} \quad (7)$$

As a note, based on Eqs. (2) and (7), if ST_{DF} decreases, it causes R_i and RC_i to become the increase but URC_I decrease.

Next, the computation of total reliability cost of each DSR_E (TRC_i) and total reliability cost of all DSR_E (TRC_E) respectively are presented as follows.

$$TRC_i = RC_I + URC_I \quad (8)$$

$$TRC_E = \sum TRC_I \quad (9)$$

2.3 Cost optimization method

After presenting CODSR model (in section 2.1 and 2.2), to achieve the minimal value of TRC_i and TRC_E, in this section, we propose three steps on CODSR model that described as follows.

Table 1. The demands of enterprise

Demand	Component	Description
D_P	DD_{P1}	Randomized number of the uniform distribution, minimum value = 0 and maximal value = EF_{DE} (1, 2, 3, or 4) (Eq. (1))
	DD_{P2}	1 if at $DT_{DS} = 15$ days, $DD_{S1} > 0$
	DD_{P3}	ARE_{DE} with $DT_{ARE} = 30$ days (Based on Eq. (6))
D_S	DD_{S1}	Randomized number of thr uniform distribution, minimum value = 0 and maximal value = EF_{DE} (1, 2, or 3) (Eq. (1))
	DD_{S2}	1 if at $DT_{DP} = 15$ days, $DD_{P1} > 0$
	DD_{S3}	ARE_{DE} with $DT_{ARE} = 30$ days
D_W	D_{PW}	D_P after $DT_{PW} = 10$ days
	D_{SW}	D_S after $DT_{SW} = 10$ days

1. In the first step, we change ST_{DF} into the increasing variable linearly, from minimal ST_{DF} at $T = 0$ to maximal ST_{DF} at last time of simulation with a Gradient value increase ST_{DF} (G_{ST}) that computed with as follows.

$$G_{ST} = \frac{\max ST_{DF} - \min ST_{DF}}{\mathrm{t}} \quad (10)$$

2. Next, in the second step, we compute R_i based on $ST_{DF} = 0$ at $T = 0$ to maximal ST_{DF} at last time of simulation with a gradient value by G_{ST} with Eq. (2), where ST_{DF} is time variable in $f(x)$ that increase linearly.
3. Finally, in CODSR model presented, we get ST_{DFO} as the optimal value of ST_{DF} based on the minimum TRC_i that computed by using Eq. (8). Next, ST_{DFO} is the fixed value of service time that used to compute the reliability and its costs.

3. Case study

To prove the CODSR model presented can be used to obtain the optimal value of dynamically service reliability (TRC_i and TRC_E), then we implement this model on a case study of the enterprise which has especially D_E. In this case study, D_E consists of IT product (D_P), IT service (D_S), and warranty of both as mandatory to guaranty to product and service have delivered to customers (D_W). Therefore D_E is shown in Table 1.

D_P has two DSR_E, that is product delivery as the first service reliability dimension (PD) and product installation as the second service reliability dimension (PI) while each D_S, D_{PW}, and D_{SW} has one DSR_E, that is service completion (SC), product warranty (PW) and service warranty (SW), respectively as a service reliability dimension. Next, if D_p, D_S, D_{PW} and $D_{SW} > 0$ then ST_{DF} of each DSR_E is generated by the randomized number of an Exponential distribution with the parameters $\min ST_{DF}$, $\max ST_{DF}$, the average of ST_{DF} (μ_{STDF}), and deviation standard of ST_{DF} (σ_{STDF}) for each DSR_E.

It is related to the data requirements of the case study, ST_{DF} of the case study presented in Table 2. The lookup function of EF (Eq. (1)) as an external factor affect the composition of IT product and service demand (D_{P1} and D_{S1}) and AR_E (Eq. (6)) as average reliability of all services affect to the component of IT product and service demand (D_{P3} and D_{S3}) are shown in Fig. 2. Next, the lookup function of RC_i and URC_i (Eq. (7)) shown in Fig. 3. These data, we have collected from the enterprise that provides IT products and services to meet the customers' need, where the values in this table result from the parameters of data testing.

3.1 Implementation of CODSR

Implementation CODSR model to the case study has the characteristic as a system dynamics that are containing feedback, time delay, and non-linearly [29, 30, 36, 37]. Therefore, implementation of CODSR model uses the system dynamics simulation by converting CLD (see Fig. 1) into a structure of stock flow diagram (SFD) as shown in Fig. 4.

3.2 Model testing

The developed SFD is tested by structural test to find out whether the model has formed a system dynamics model and have the units appropriately. The structural testing shows SFD is the closed system, no terminate variable and containing the negative feedback that is caused by the relationship between ST_{DF} and R_i . In this SFD, the closed system achieved by adding accumulation of AR_E (AAR_E), accumulated of AR_E (AcR_E), and accumulation of TRC_E $(ATRC_E)$ as the stock variables in SFD of CODSR. Next, as the stock variable in SFD, after AAR_E, AcR_E and $ATRC_E$ must add the outflow variables, that are the outflow of average reliability on enterprise (OAR_E), outflow of reliability on enterprise (OR_E), and total reliability cost of enterprise $(OTRC_E)$ (see Fig. 4). In this CODSR model, D_E has product/day as a unit for D_P and D_{PW} and service/day for as a unit for D_S and D_{SW}. Next, TRC_i and TRC_E have the dollar as a unit, while R_i, and AR_i are dimensionless (dmnl).

3.3 Scenario simulation

To simulate the case study implemented on CODSR model, we use two scenarios. Scenario 1 is the simulation of CODSR model using ST_{DF} that generated by an exponential number generator (see Table 2). While scenario 2, as an improvement, is the optimization scenario that simulates CODSR model using ST_{DFO}.

However, before simulating the Scenario 2, we must find the optimized value of each DSR_E (TRC_{iO}) and the optimized value of each DSR_E (TRC_{EO}). The optimized values is resulted from the addition of reliability cost and unreliability cost by following the steps of the cost optimization method (Section 3.3). For this work, we simulate the CODSR model on the case study with both scenario during simulation time $T = 0$ to $T = 100$ day.

4. Result

In this section, the results of scenario simulation 1 and 2 presented in section 5.1 and 5.3. While the results of the optimization value of TRC_i presented in section 5.2.

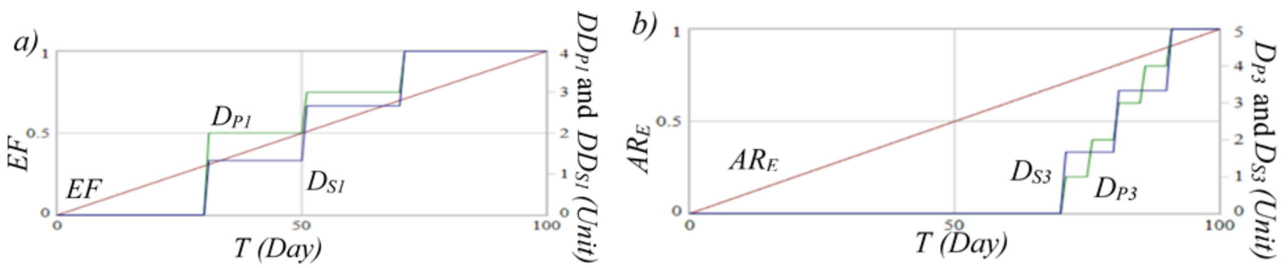
4.1 Result of scenario simulation 1

The results of scenario simulation 1 shown in Fig. 5 in the form of the dynamic behaviour of demands, reliabilities, average reliabilities, and total reliability costs, which each are for $DSR_E = PD, PI, SC, PW, \text{and } SW$. The demands consist of $D_P, D_{PW}, D_S, \text{and } D_{SW}$ that occur dynamically at $T = 0 \text{ to } T = 100$ day (Fig. 5 (a)). In this result, when there is no demand, then reliability is 0. The reliability of individual service is dimensionless having a value minimal 0 and maximum 1 (Eq. (2)) (Fig. 5 (b)).

In this reliability values, R_E is always bigger than each R_i for $i = PD, PI, SC, PW, \text{and } SW$ (Eqs. (2) and (3)). Based on Eq. (3), if at $T = t, R_E = 0$ that means all $R_i = 0$ at the time. Next, AR_i occurs every for interval time for computation of average reliability (IT_{AR}) (Fig. 5 (c)) having a value minimal 0 and maximum 1 (Eq. (4)). In this average reliability values, different from R_E, AR_E can be smaller than AR_i for $i = PD, PI, SC, PW, \text{and } SW$ (Eqs. (4) and (5). If every IT_{AR}, $AR_E = 0$ that means all $AR_i = 0$ at the same time.

Table 2. Parameter of exponential distributions of service time

Parameter	Value (unit)
$ST_{PD_{min}}$, $ST_{PD_{max}}$, $\mu_{ST_{PD}}$, and $\sigma_{ST_{PD}}$	1.75, 3.78, 2.21, and 0.5 (day)
$ST_{PI_{min}}$, $ST_{PI_{max}}$, $\mu_{ST_{PI}}$, and $\sigma_{ST_{PI}}$	0.6, 0.96, 0.702, and 0.1 (day)
$ST_{SC_{min}}$, $ST_{SC_{max}}$, $\mu_{ST_{SC}}$, and $\sigma_{ST_{SC}}$	2.76, 6.92, 4.29, and 1.5 (day)
$ST_{PW_{min}}$, $ST_{PW_{max}}$, $\mu_{ST_{PW}}$, and $\sigma_{ST_{PW}}$	0.55, 0.94, 0.651, and 0.1 (day)
$ST_{SW_{min}}$, $ST_{SW_{max}}$, $\mu_{ST_{SW}}$, an d $\sigma_{ST_{SW}}$	1.25, 1.95, 1.47, and 0.3 (day)
$\mu_{RF_{PD}}$, $\mu_{RF_{PI}}$, $\mu_{RF_{SC}}$, $\mu_{RF_{PW}}$, $\mu_{RF_{SW}}$, and EF	2.21, 0.702, 4.29, 0.651, 1.47 (day), 0.6
$ST_{PD_{min}}$, $ST_{PD_{max}}$, $\mu_{ST_{PD}}$, and $\sigma_{ST_{PD}}$	1.75, 3.78, 2.21, and 0.5 (day)
$ST_{PI_{min}}$, $ST_{PI_{max}}$, $\mu_{ST_{PI}}$, and $\sigma_{ST_{PI}}$	0.6, 0.96, 0.702, and 0.1 (day)
$ST_{SC_{min}}$, $ST_{SC_{max}}$, $\mu_{ST_{SC}}$, and $\sigma_{ST_{SC}}$	2.76, 6.92, 4.29, and 1.5 (day)
$ST_{PW_{min}}$, $ST_{PW_{max}}$, $\mu_{ST_{PW}}$, and $\sigma_{ST_{PW}}$	0.55, 0.94, 0.651, and 0.1 (day)
$ST_{SW_{min}}$, $ST_{SW_{max}}$, $\mu_{ST_{SW}}$, and $\sigma_{ST_{SW}}$	1.25, 1.95, 1.47, and 0.3 (day)
$\mu_{RF_{PD}}$, $\mu_{RF_{PI}}$, $\mu_{RF_{SC}}$, $\mu_{RF_{PW}}$, $\mu_{RF_{SW}}$, and EF	2.21, 0.702, 4.29, 0.651, 1.47 (day), 0.6



(a) (b)

Figure 2. (a) The value of external factor (EF) affect to the demands (DD_{P1} and DD_{S1}) and (b) The value of average reliability affect (AR_E) to the demands (D_{P3} and D_{S3})

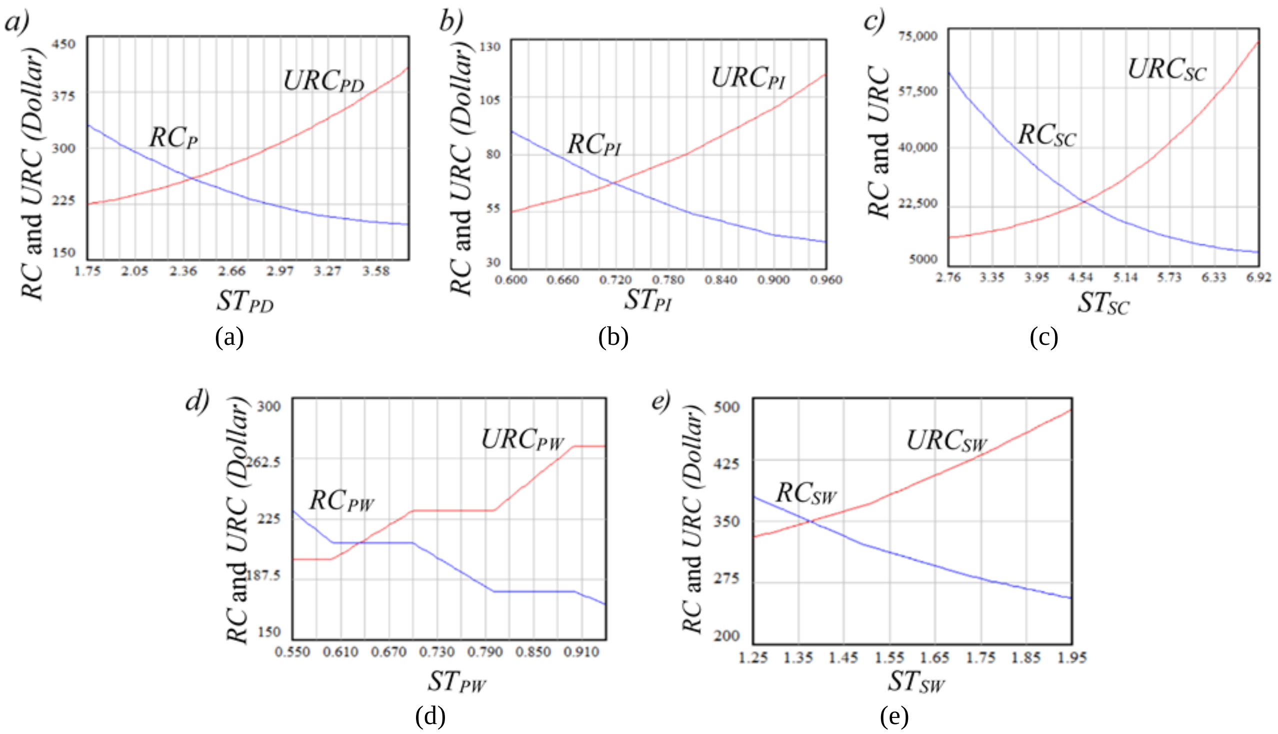


Figure. 3 Reliability cost and unreliability cost as the values are resulted from lookup function based on service time: (a) product deliver, (b) product installation, (c) service completion, (d) product warranty, and (e) service warranty

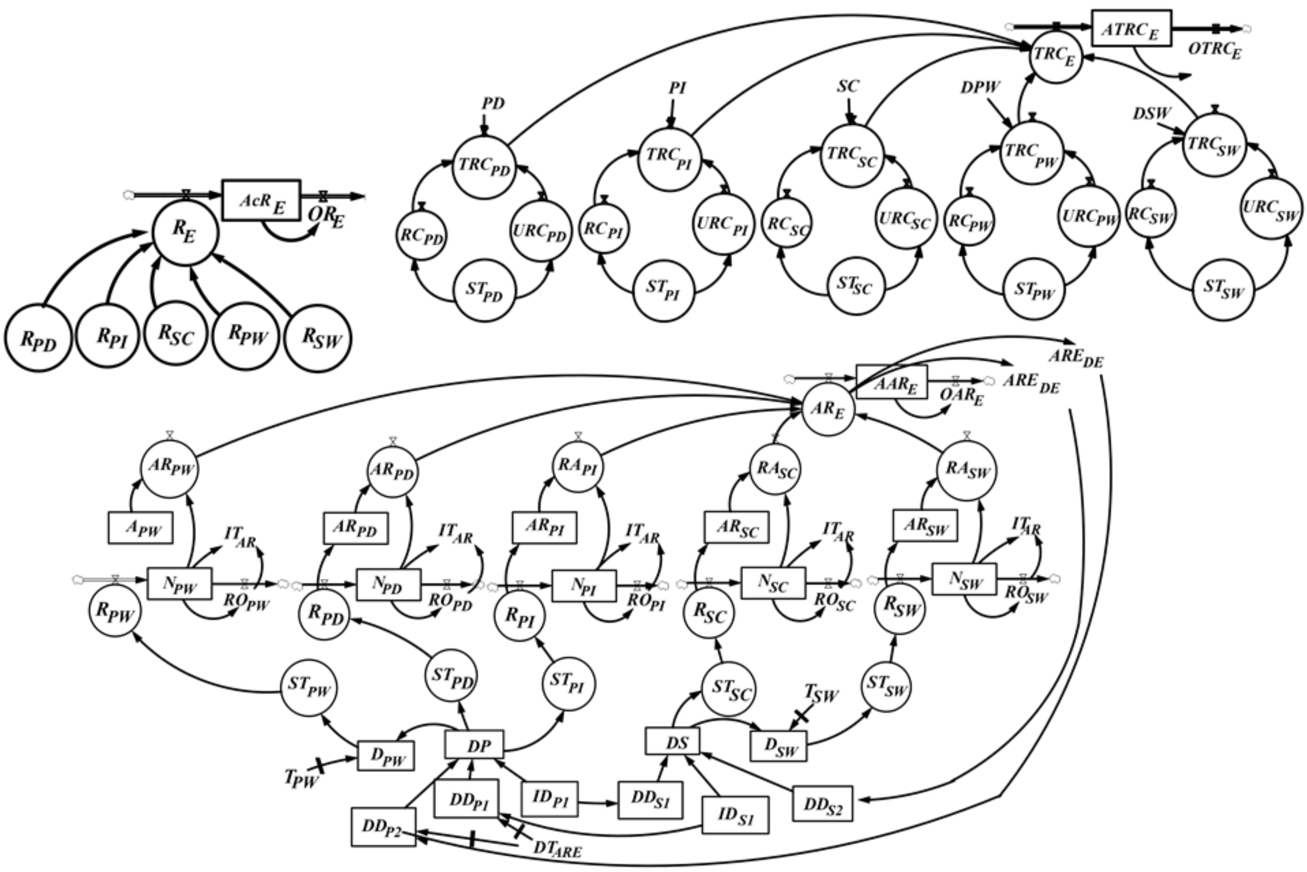
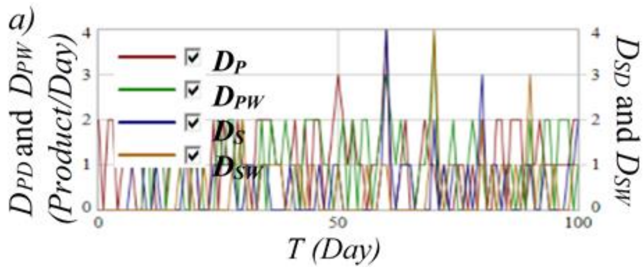
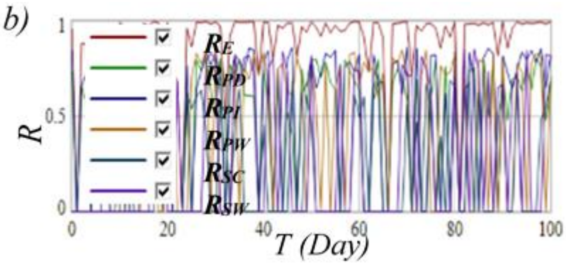


Figure. 4 SFD of CODSR implemented to the case study



(a)



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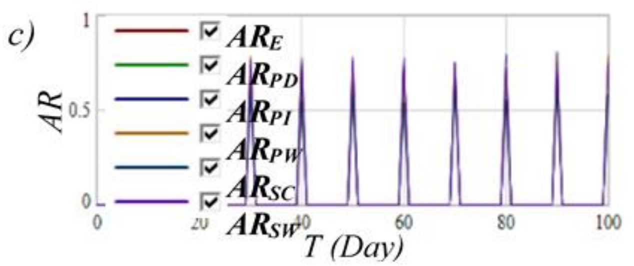
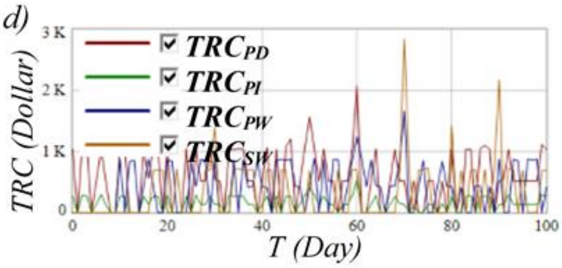
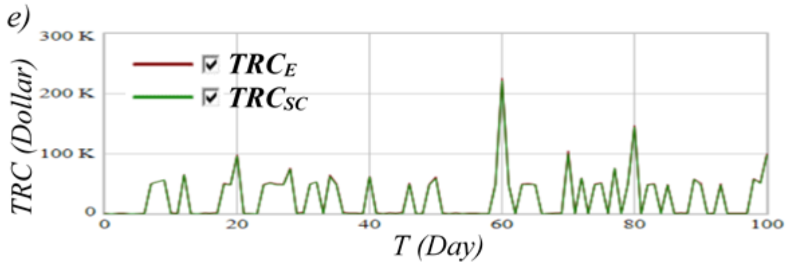


(c)

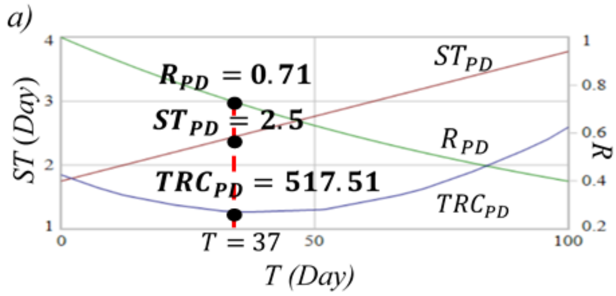


(d)

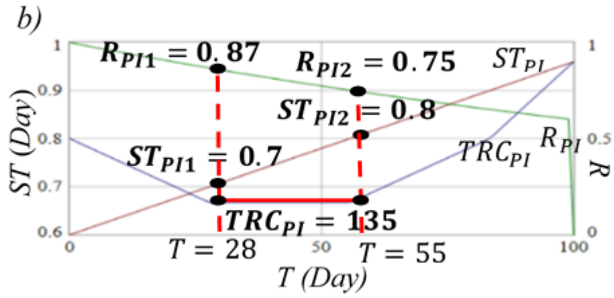


(e)

Figure. 5 Results of scenario simulation 1 in the form of dynamic behavior of: (a) Demands, (b) Reliabilities, (c) Average reliabilities, (d) Total reliability costs of PD, PI, PW, and SC, (e) Total reliability costs of PD and E



(a)



(b)

Figure 6. Optimal value of service time result the minimum total of: (a) TRC_{PD} and (b) TRC_{PI}

Next, TRC_i separated in Fig. 5 (d) for TRC_{PD}, TRC_{PI}, and TRC_{PW}, and TRC_{SW}) and Fig. 5 (e) (for TRC_{SC} and TRC_E) (Eqs. (8) and (9)). This separation is done because there is a big difference between the two groups of total reliability cost (see Fig. 3).

4.2 Result of cost optimization

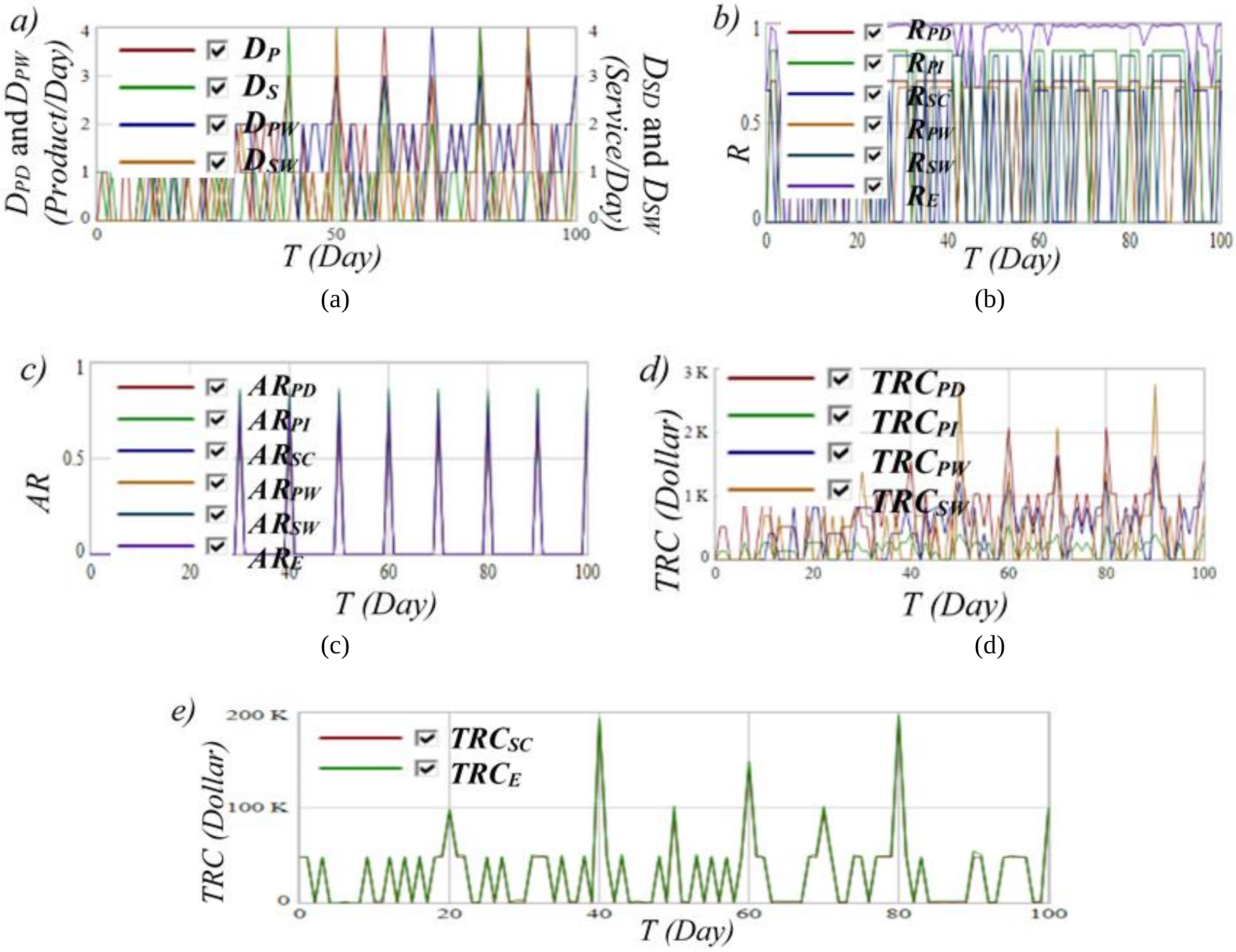
After simulation with Scenario 1, the results cost optimization method in this case study presented as follows.

- Step 1: G_{ST} for DSR_E for PD, PI, SC, PW and SW are 0.0203, 0.0036, 0.0416, 0.0039, and 0.007 respectively (use Eq. (7)).

Step 2 and 3: These steps result in R_i and the optimal value of ST_{DF} (ST_{DFO}) that provide the minimal of TRC_i for $DSR_E = PD, PI, SC, PW$ and SW. Therefore, as evidence, Fig. 6 especially show how R_i, ST_{DFO}, and TRC_i for PI and PD resulted by these steps. Next, all result of these steps summarized in Table 3.

Table 3. Optimized value of ST_{IO}, R_I that result TRC_{IO}

DSR$_E$	***T***	***TRC$_i$***	***R$_i$***	***ST$_{DFO}$***
PD	37	517.51	0.71	2.5
PI	28 to 55	135	0.87 to 0.75	0.7 to 0.8
SC	42 to 53	4800	0.67 to 0.6	4.51 to 4.96
PW	64	410.12	0.68	0.8
SW	35	690.16	0.84	1.5



(a) (b) (c) (d) (e)

Figure 7. Results of scenario simulation 2 in the form of dynamic behavior of: (a) demands, (b) reliabilities, (c) average reliabilities, and (d) Total reliability costs for $DSR_E = PD, PI,\ PW, and\ SW$, and (e) DSR_E and TRC_{CS}

4.3 Result of scenario simulation 2

While the results of scenario simulation 2 (the improvement scenario) are shown in Fig. 7. In this scenario, the total of D_P and D_{PW} increase, but total D_S and D_{SW} decrease during simulation time (Fig. 7 (a)). Next, the increasing of D_P and D_{PW} is followed by $R_{PD}, R_{PI},$ and R_{PW} and the decreasing of D_S and D_{SW} followed by R_{SC} and R_{SW}. Each R_i in this scenario is constant (Fig. 7 (b)). Same as scenario simulation 1, in this scenario, R_E is always bigger than each R_i for $i = PD, PI, SC, PW,$ and SW.

In this result, the average reliability of the individual service also has fixed value and equal with the reliability of individual service ($AR_i = R_i$, for $DSR_E = PD, PI, SC, PW,$ and SW). Where, the value of AR_i for $DSR_E = PD, PI, SC, PW,$ and SW is $0.71, 0.87, 0.67, 0.68,$ and 0.84 respectively (Fig 7 (c)). It is caused ST_{DFO} for PI and SC that are chosen the minimum ST_{DFO} (0.7 and 4.51) so customers will get the faster service time.

Next, for the same reason as Fig 5 (d), the total reliability costs in Fig 7 (d) are separated, that is $TRC_{PD}, TRC_{PI}, and\ TRC_{PW},$ and TRC_{SW}. During this simulation time, the total, number of events, the

Table 4. The results of both Scenario 1 and 2

Variable	Summarize	Scenario 1	Scenario 2	Variable	Summarize	Scenario 1	Scenario 2	Variable	Summarize	Scenario 1	Scenario 2
D_P	T	101	121	R_{PW}	N	55	65	TRC_{PD}	T	53365	62619
	N	64	70		A	0.75	0.68		N	64	70
	A	1.57	1.72	R_{SW}	N	52	44		A	834	895
D_S	T	63	62		A	0.78	0.84	TRC_{PI}	T	13928	16335
	N	58	50	R_E	N	95	96		N	64	70
	A	1.09	1.24		A	0.94	0.95		A	218	233
D_{PW}	T	88	111	AR_{PD}	N	10	10	TRC_{SC}	T	3265618	2976000
	N	55	65		A	0.66	0.71		N	58	50
	A	1.6	1.7	AR_{PI}	N	10	10		A	56304	59520
D_{SW}	T	55	55		A	0.77	0.87	TRC_{PW}	T	37840	45523
	N	52	44	AR_{SC}	N	10	10		N	55	65
	A	1.06	1.25		A	0.58	0.67		A	688	700
R_{PD}	N	64	70	AR_{PW}	N	9	9	TRC_{SW}	T	38565	37959
	A	0.65	0.71		A	0.75	0.68		N	52	44
R_{PI}	N	64	70	AR_{SW}	N	9	9		A	742	863
	A	0.76	0.87		A	0.78	0.84	TRC_E	T	3409315	313595
R_{SC}	N	58	50	AR_E	N	10	10		N	95	96
	A	0.58	0.67		A	0.7	0.75		A	35888	32692

average of TRC_{SC} as well as the total and number of events TRC_{SW} decrease. While the total, number of events, the average of other TRC_i increase. As a comparison of the result between Scenario 1 and Scenario 2, the most important factor to note is TRC_E. Where, in this scenario, TRC_E decreases.

For easy comparing, both results of these scenarios summarized in the total value (T), the number of events (N), and the average (A) as shown in Table 4. The summarize of both simulation result show the result of Scenario 2 (scenario simulation use ST_{DFO}) not all smaller than Scenario 1 (Scenario simulation use the randomized value of ST_{DF}).

5. Conclusion

In this article, we successfully presented CODSR model that can be used to compute dynamic service reliability and proposed the cost optimization method to achieve the optimal value of TRC_i and TRC_E by optimized service time that can find minimize the total of reliability cost, and unreliability cost.

Next, we implement CODSR model on the case study of demand fulfillment of the enterprise with system dynamics simulation for Scenario 1 to obtain the demand ($D_P, D_S, D_{PW},$ and D_{SW}), reliability (R_i for $i = PD, PI, SC, PW, SW,$ and R_E average reliability (AR_i for $i = PD, PI, SC, PW, SW,$ and AR_E) and total of reliability cost dynamically (TRC_i for $i = PD, PI, SC, PW, SW,$ and TRC_E) during simulation time 100 days. Next, based on the cost optimization method, we simulate CODSR model for scenario 2 as the improvement scenario.

Finally, the results of both simulations show that substitution of the random service time (ST_{DF}) with the optimized service time (ST_{DFO}) can cause the increase and decrease in the total reliability cost of individual service (TRC_i) while the overall total reliability cost of all services (TRC_E) is decreased ($ 3,409,315 became $ 313,595). Overall, we can conclude that the result of scenario simulation 2 is better than scenario simulation 1.

In the future work, as a continuation of this article, we will develop a scenario by changing TRC_i (RC_i and URC_i) and simulate to know the change in ST_{DF} and other variables in the model.

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