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광 버스트 스위칭에서 버스트 길이의 동적 조절을 통한 QoS 향상방법

(QoS Improvement Scheme in Optical Burst Switching using Dynamic Burst length Adjustment)

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(Sanghoon Hong and Sungchang Lee)

요 약

본 논문은 Offset time을 기반으로 하는 OBS에서 하위 우선순위 클래스의 버스트 크기를 망의 트래픽 부하에 따라 동적으로 조절하여 하위 우선순위 클래스의 손실율을 제어 시킬 수 있는 방안을 제안한다. 이 방안에서는 void를 활용하는 스케쥴링에서는 부하가 증가함에 따라 긴 버스트의 손실율이 짧은 버스트의 손실율보다 높아지므로, 부하가 높아 질 때에는 버스트의 길이를 짧게 함으로써, 채널의 void/gap을 보다 효율적으로 활용하여 클래스간의 버스트 충돌을 감소시킬 수 있다는 사실을 이용한다. 이 방안의 구현을 위해서 먼저 버스트의 길이와 버스트 loss율 그리고 트래픽 부하에 대한 상관관계를 구하여, 코어 라우터에서는 망의 부하에 따라 유지하고자하는 버스트 손실율에 상응하는 burst 길이를 Ingress 에지 라우터(edge router)에 주기적 혹은 필요에 따라 피드백 해준다. 에지 라우터는 피드백 받은 정보에 따라 어셈블리 때에 Burst Assembly Threshold를 조정하여 버스트 길이를 제한하게 된다. 시뮬레이션 결과를 통하여 제안한 방안이 하위 우선 순위 버스트들의 손실율을 망이 요구하는 수준으로 잘 유지 할 수 있음을 확인 할 수 있었다.

Abstract

In this paper, we propose a scheme that can control the loss probability of low priority class bursts by dynamically adjusting the assembly threshold of low priority class. The key ideas is that the loss probability of the longer burst increases as the load increases, thus reduced low priority class burst length decreases the loss priority at high traffic load. To achieve this aim, we first derive the relation among the loss probability, the assembly threshold, and the traffic load. In this paper we derive the relation by curve fitting on the simulation results. The ingress edge routers periodically or by event-driven receives the proper corresponding assembly threshold information from the core routers. This assembly threshold is calculated from the derived relation so that the required loss probability of the low priority class bursts in the network is satisfied. The simulation results show that the proposed scheme performs well to meet the loss probability target as expected.

Keywords : *Optical Burst Switching, Feedback. Scheduling, Burst Assembler*

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I. Introduction

The bandwidth demand on the Internet is rapidly growing due to emerging multimedia application. WDM[1] networks are attractive in the next generation Internet due to their huge deliverable bandwidth. Nowadays, IP over WDM networks have received much attention as it can reduce complexities and overhead associated with ATM and SONET layer. This WDM technology leads to the concepts of "Burst Switching" where several IP packets with the same destination and some common attributes like quality of service(QoS) are assembled into a burst and are forwarded through the networks. In the next generation optical Internet, one must address, among other issues, how to support Quality of Service(QoS) at WDM layer[2, 3]. Existing QoS schemes are based on packet switching, and mandate the use of buffer to isolate different classes of traffic. We call these the buffer-based schemes. While the offset-time based QoS schemes which are based on OBS[4, 5] uses an offset-time instead of buffer to isolate classes of traffic. It is suitable for implementation in buffer-less WDM networks as it does not mandate the use of any buffer. The novel scheme to be studied in this paper is based on the concept of optical burst switching(OBS). In the following, We describe in more detail the function of the OBS network architecture Within an WDM networks, the OBS nodes are classified as edge node and core node An ingress OBS node assembles IP packets into bursts and sends out a corresponding control packet for each data burst. This control burst is delivered out of band and leads the data burst by an offset time. The control packet can provide ingress to egress transparent optical paths for transporting data burst. The offset time is time to process the control burst and it need to be increased in proportion to the number of hops from ingress node to egress node.

In OBS, the proposed QoS scheme uses an extra offset time which isolates a higher priority classes from lower priority classes. Although the extra-offset time increase the pre-transmission delay but degree of isolation increase, resulting in reduced blocking probability for high priority classes.

The optical core node which mainly consist of FDL(fiber delay line), an optical switching matrix, a switch control unit(SCU). When control packet arrives at core node. the SCU decides outgoing data channel and control channel to forward each arriving data burst and its control packet. Specifically, in order for higher priority class to have a higher priority than lower priority class for reserving resources such as wavelengths and FDLs, an extra offset time. Since, it has a higher priority reserve the wavelength, the lower priority class' data burst scheduled at void/gap after higher priority class' burst reserved the wavelength. Moreover the output channels' void/gap is more smaller by traffic is increased and lower priority class' data burst more difficult to reserve wavelength.

In this paper, We investigate a new OBS paradigm based on offset time based QoS and control plane protocol such as GMPLS, which can improve the low class's channel utilization by decrease low class's burst length as in put IP traffic proportionally.

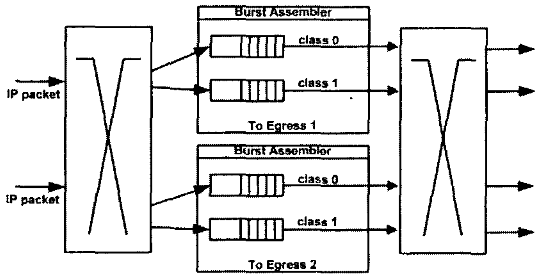
The paper is organized as follows. Section 2 gives an overview of key algorithm of optical burst switching. In Section 3, our new approach to decrease lower priority class' burst loss probability by decrease the lower priority class' burst length proportionally as input IP traffic. Section 4 shows numerical results from simulation with PARSEC, followed by concluding remarks in Section 5.

II. The algorithm of OBS

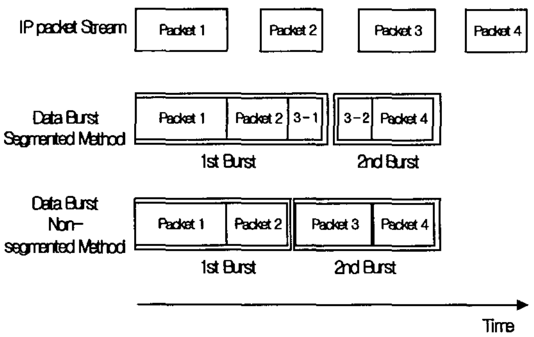
1. Burst Assembly Algorithm

An example of burst assemble process is illustrated at Fig .1(a). The Ingress edge node of an OBS networks assemble bursts by merging IP packets. IP packets are reached at Ingress edge node which then switched to the burst assemble buffer. The incoming

IP packets are classified and queued into an assembly buffer according to their destination and QoS requirement. Thus the number of the burst assemble buffers depends on the number of egress edge routers and the number of QoS service classes supported. The burst assembler controls the timer, which expires at a given time. Whenever the timer expires, the burst assembler takes the burst out of the assemble buffer for transmission. Depending on the distribution of the assemble time.



(a) 데이터 버스트 어셈블러 구조
(a) Data burst Assembler



(b)데이타 버스트 어셈블리 방법
(b) Data burst assembly method

그림 1. 버스트 어셈블리 구조
Fig. 1. Burst Assembly architecture.

The burst assemble schemes are classified into a constant assemble time(CAT),a variable assemble time(VAT), and an adaptive assemble time(AAT) scheme. In this study, we uses AAT assembly algorithm. The timer in the AAT scheme expires with two conditions: When the given assemble time expires or when the assembled data burst reached to the size threshold. And we can consider two ways to assemble multiple IP packets into an optical data burst as shown in Fig. 1(b). The first segmented method separates IP packets whenever necessary while the non-segmented method constructs earlier data bursts and puts IP packets in later data bursts. The segmented method offers high bandwidth utilization but requires complex hardware. The non-segmented method can be achieved more easily than segmented methods. In OBS, the processing burden is heavy in the ingress and egress nodes and the non-segmented method is better suited in OBS.

2. Data Channel Scheduling Algorithm

Data channel scheduling algorithms can be classified into two categories : with and without void filling(VF). LAUC(latest available unscheduled channel)algorithm is s simple scheduling algorithm without void filling. And in this paper, we uses the void filling algorithm which is called LAUC-VF(latest available unscheduled channel). This algorithm is similar to the LAUC algorithm except the voids can be filled by new arriving data bursts. The basic idea of the LAUC-VF algorithm is to minimize voids by selecting the latest available unused data channel for each arriving data burst. Given the arrival time t of a data burst with duration L to the optical switching matrix, the scheduler first finds the outgoing data channels that are available for the time period of(t,t+L). If there is at least one such data channel, the scheduler selects the latest available data channel,

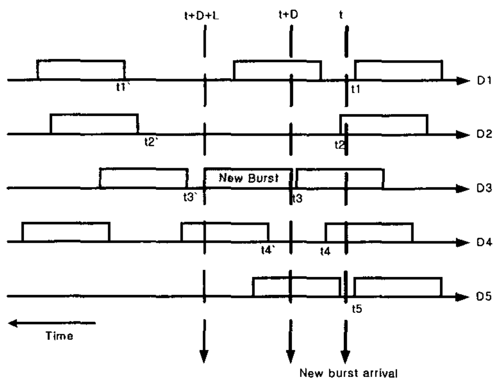


그림 2. LAUC-VF 알고리즘 동작방식
Fig. 2. Illustration of LAUC-VF algorithm.

i.e., the channel having the smallest gap between t and the end of last data burst just before time t.

An example of data channel scheduling process with LAUC-VF is illustrated at Fig. 2. In Fig. 2, The data channel group has 5 data channels where all data channel is ineligible at time t for carrying the data burst. Specifically D1 and D5 are ineligible at time t because the void is too small on D1 and D5 for the data burst. And the other channels were already scheduled at time t. Since all the data channel are ineligible at time t, the scheduler will then try to find the outgoing data channels that are eligible at time t+D..[i.e., for the time period of(t+D , t+D+L)], and so on. Note that voids could be generated due to different data burst arrival times 개 FDL buffer increments. Obviously, the larger the FDL unit D, the bigger the void could be. Channel D2 and D3 are eligible at time t+D. and D3 is chosen to carry the data burst as t+D-t2>t+D-t3. If no data channels are found eligible up to time t+B, the arriving data burst and the corresponding control packet are dropped. Note that B constitutes the longest time the data burst can be delayed.

III. The Offset time based QoS Scheme with FDLs

1. Burst Contentions in Offset Time based QoS Scheme

Offset-time based QoS scheme uses an extra offset time which isolates a higher priority classes from lower priority classes. As the extra-offset time increases the degree of isolation also increases, resulting in reduced blocking probability for high priority classes[6]. For simplicity, we confider two classes of traffic in the following discussion, i.e., class 0 and class 1, where class 1 has a higher priority with extra offset time over class 0.

There are two different kinds of burst contentions in reserving resources: the intra class contention caused by requests within the same class, and the inter class contentions caused by requests from different classes. In the extreme case where the extra offset time for high priority class is larger than the maximum burst length of the low class, the high priority class will have total isolation from the low class. Then, Class 1 bursts will have only intra contention, but the class 0 will have the intra and inter class contention. As the extra offset time decreases the degree of isolation decreases, and the loss probability of class 1 burst increases by contention with class 0 bursts.

2. The relation between burst length and collision

Assuming that the isolation of the high priority class from the low priority class is provided with enough extra offset time for high priority class, we concentrate the discussion on the relationship between the burst length and the loss probability of low priority class. It was shown that the output channel's void/gap tends to get more smaller and the successful reservation probability of class 0 decreases. Specifically, a burst with smaller size will have more probability to fit into those voids, and the larger burst will have higher loss probability[7].

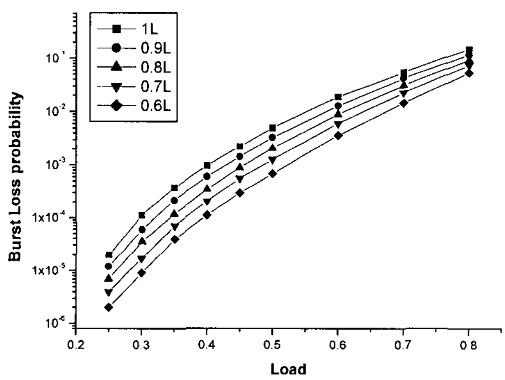


그림 3. class 0의 버스트 손실확률
Fig. 3. Class 0's Burst Loss probability.

In Fig. 3, the class 0's burst loss probability is shown as a function of the traffic intensity and the burst length. In the simulation, the number of edge router and the number of the output wavelengths are N=32, and k=2, respectively. The edge routers uses AAT[8, 9], where the burst length threshold is L in assembly. The delay unit of FDL was chosen $D = \alpha \cdot L$, and there are m FDLs with delay unit D. Thus, the maximum delay is $B=m \cdot D$. The number of output channel is k =2, and the traffic load $\rho = (\sum \rho$ class j)/k (j =0,1) and the each of the two classes has equal traffic load. Also, it is assumed that half of the edge router generates the low priority traffic, the others generates the high priority traffic.

To evaluate the relation between burst length and burst loss, we performed the simulations changing the burst length from $1 \cdot L$ to $0.6 \cdot L$ for different traffic intensities. As can be observed from the figure, the loss probabilities of low priority class decreases as the burst length decreases from $1 \cdot L$ to $0.6 \cdot L$.

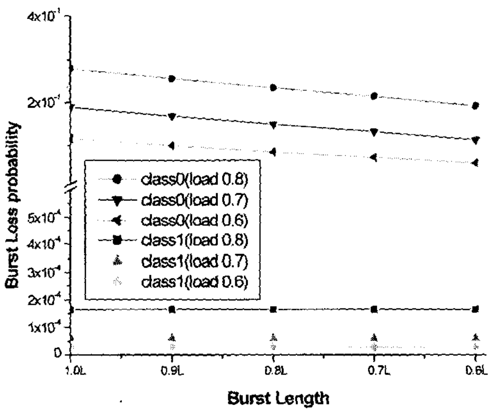


그림 4. 클래스 각각의 버스트 손실확률
Fig. 4. Burst Loss Probability of classes.

In Fig. 4, the classes' burst loss probability is shown as a function of the traffic intensity and the burst length. In the simulation the number of output wavelength k=1 and the other simulation environmen ts are same with Fig. 3. In Fig. 4, we change the burst length from $1 \cdot L$ to $0.6 \cdot L$ for fixed traffic intensities. As you known figure, class 0's burst loss probability is decreased as burst length shorten.

But class 1's burst loss probability is constant. Our explanation is as follow. Since class 1's bursts with extra offset time will break the channel's free period into discrete small void/gap. Therefore, a burst with smaller size will have more probability to fit into those voids. So as class 0's burst size smaller as the channel utilization is better and class 1 don't affected by class 0's burst length variety.

3. Loss Control for by Load Status Feedback

In this sub-section, we propose a new burst control scheme to reduce the loss probability of low priority class. We assume GMPLS control plane is running over the OBS network. In this scheme, the core routers feedback the load status information using GMPLS signaling to the ingress edge routers with which LSPs are set up. The main idea behind the scheme is that we can expect the loss probability of the low priority class' bursts from the relationship between the burst length and load of Fig. 3. if we know the current traffic load of core router. If there is a specified loss probability requirement for low priority class bursts and if the loss is expected to surpass the loss limit, then the edge routers reduce the maximum length threshold in burst assembly. The load status of the core router information (or the required burst length threshold information) can be sent from the core router to the edge routers with which LSPs are set up. The information can be sent periodically or only when the reduction of maximum burst length threshold is required.

In the simulations, we assumes that OBS network consists of N ingress edge routers and one core router.(Fig. 5) The class 1 bursts have extra offset time, τoffset, and class 0 bursts does not. The basic

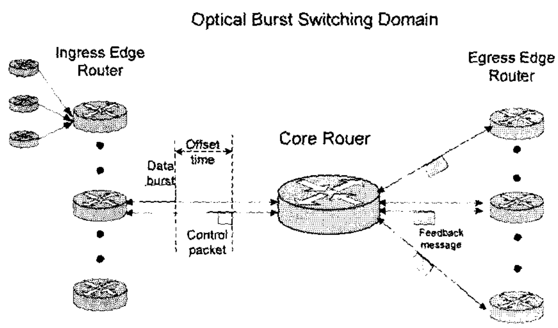


그림 5. OBS 네트워크
Fig. 5. OBS Networks.

offset time that is the same for all bursts, τ0 is set by ingress edge routers. But the basic offset time τ0 is very small compared to extra offset time, so it can be ignored in this discussion. The optical switching matrix is assumed to be non-blocking switch, which switches each burst on an incoming wavelength as it arrives. The input burst may be delayed zero to $m \cdot D(D = \alpha \cdot L)$.

As mentioned earlier, L is the maximum burst length limit at the burst assembly. In the simulation, m=15, and α=0.3 are used.

By using GMPLS protocol, it is possible to set up label switched path(LSP) and transmit control packet and data burst. Control packet contains not only traditional information to control data burst but also label information related with GMPLS for finding, making, and recovering LSP. Moreover, This LSP is a bidirectional transmission path formed by signaling protocol and by routing protocol.

4. Derivation of the relationship between the load and burst length

In order to control the loss probability of the low priority class bursts, we need to know the relationship between the loss probability, burst length, and the core router load. In this paper, the relationship is not derived analytically, but from the simulation results. The analytical derivation is under study. Once this relationship is known, the edge router or the core router can estimate the proper burst length assembly threshold. By receiving the load status information from the core routers that the LSPs go through, the edge routers can dynamically adjust the burst length assembly threshold so that the loss probability requirement is met. This action can be initiated by the core router or the edge router according to the network operating policy.

Let the loss probability requirement be lclass 0 and burst assembly threshold $\beta \cdot L$ $(0 \leq \beta \leq 1)$and the current traffic intensity of core router ρ.

The relationship can be derived from the figure 5 which is redrawn version of Fig. 3. Using curve fitting technique for Fig. 5, we obtain the equation between traffic intensity, burst length and burst loss probability. The equation is derived as

$$\beta = C_1 + C_2 \cdot \rho + C_3 \cdot \rho^2 \qquad (1)$$

when,

$$\begin{pmatrix} C_1 \\ C_2 \\ C_3 \end{pmatrix} = \begin{pmatrix} 3.394 & -4743 \\ -12.131 & 39059.75 \\ 11.297 & -53215.5 \end{pmatrix} \bullet \begin{pmatrix} 1.0 \\ l_{class0} \end{pmatrix} \qquad (2)$$

The equation (1) is the relation between the traffic intensity, the burst length, and burst loss probability. According to this equation, the core routers or the ingress edge routers can estimate the proper burst length threshold to meet the loss probability requirement.

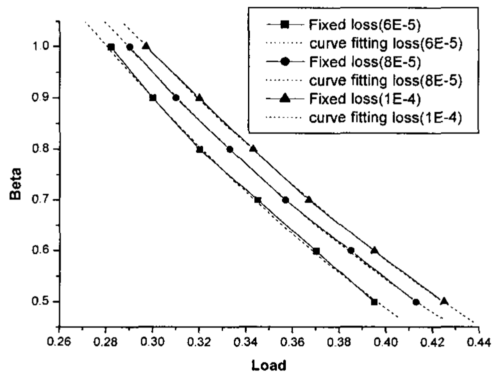


그림 6. 부하의 변화에 대한 β값
Fig. 6. Load versus Beta(β).

Ⅳ. Simulation Results

The results from simulation are presented in this section. As to the traffic model for the simulation, we assume Poisson arrival and exponential distribution length for the packets that arrive at the ingress edge routers.

In the simulation, it is assumed that the output link of the core router has 2 wavelengths and the distance between the edge router and the core router is 200km(thus, the propagation delay is 10^{10} ps). The input bursts can be delayed from zero to up to $15 \cdot D$

for the contention resolution in the reservation, where D = α · L and α is 0.3. We use assembly scheme that based on AAT, but the difference with the original AAT is that the assembly threshold changes dynamically. In the simulation, the initial assembly threshold, L, is 5 · 106 ps and assembly period is 3 · 10^8 ps. The mean length of the input IP packets is 10^4ps. The extra offset time is 1L, and LAUC-VF data channel scheduling algorithm is used in the simulation.

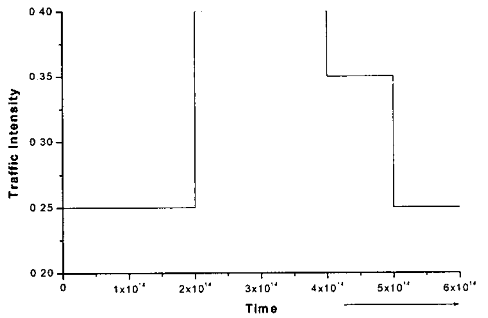


그림 7. 시뮬레션 입력 트래픽
Fig. 7. Input traffic used for the simulation.

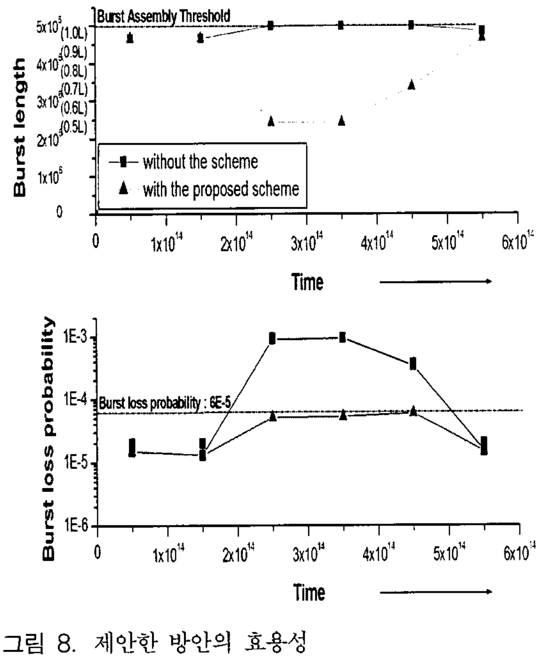


그림 8. 제안한 방안의 효용성
Fig. 8. Efficiency of the proposed scheme.

In this chapter, we show that the efficiency of the proposed control scheme to regulate the loss probability of the low priority class bursts to satisfy the loss requirement. The core node measures its traffic load, and it calculates the value of β from equation (1) with the given loss probability lclass 0. The value of β is sent to the ingress edge routers periodically. The ingress edge routers receive β value periodically, and adjust the maximum burst assembly length(assembly threshold) dynamically. This control scheme will regulates the loss of the low priority class bursts so that it does not surpass the preset loss requirement.

Fig. 8 shows the simulation results of the loss probability of the class 0 bursts when N=32, k=2, B=15 · D (D = 0.3 · L), and the traffic shown in Fig. 7 is applied to the core node. Total simulation time is 6 · 1014 ps. The figure on top shows the mean length of the assembled bursts in each period. It can be observed that the mean burst length decreases as the traffic increases according to the equation when the proposed scheme is used, whereas the mean length remains almost the same except the slight increase due to the load increase when the scheme is not used. The bottom figure shows the corresponding loss probability results. The horizontal guideline shows the loss probability object of the core network. As can be seen, the proposed loss control scheme maintains the loss probability to the loss requirement. On the other hand, the loss of the bursts is untethered without the proposed scheme. In the simulation the loss probability object was set to 6 · e-5. From the simulation result, we can observe that the proposed scheme effectively controls the loss probability of the low priority class bursts. The simulation in this paper involves one core router only to prove the feasibility of the proposed concept, it can be extended to multiple core routers cases. In this case the ingress edge routers receives the feedbacks from the core routers through which it has LSPs. This study is under progress.

V. Conclusions

In this paper, we propose a new scheme to control the loss probability of the low priority class bursts in the offset time based OBS QoS environment. Based on the notion that the loss probability of longer low priority bursts increases as the traffic load increases, the ingress edge routers dynamically adapt the burst length threshold in burst assembly according to the feedback infomation from the core routers. The relationship among the loss probability, the burst length threshold, and the core router traffic load is utilized to estimate the expected loss probability of the low priority bursts at given traffic load. In this paper the relation is derived from the simulation results by curve fitting. The analytical derivation is under study. The traffic load or the required burst length threshold information can be sent from the core routers to edge routers using control plane protocols such as GMPLS. The actions to adjust the burst length threshold to meet the loss requirement can be initiated by core routers or edge routers according to the network operation policy. Also, the information feedback can be done periodically or by event-driven.

The simulation results show that the proposed control scheme performs well to meet the loss probability of the low priority class bursts in the offset time based QoS OBS. Further studies are being done including analytical derivation of relationship.

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