Detection of Bottleneck in Manufacturing Supply Chain using Specific KPI

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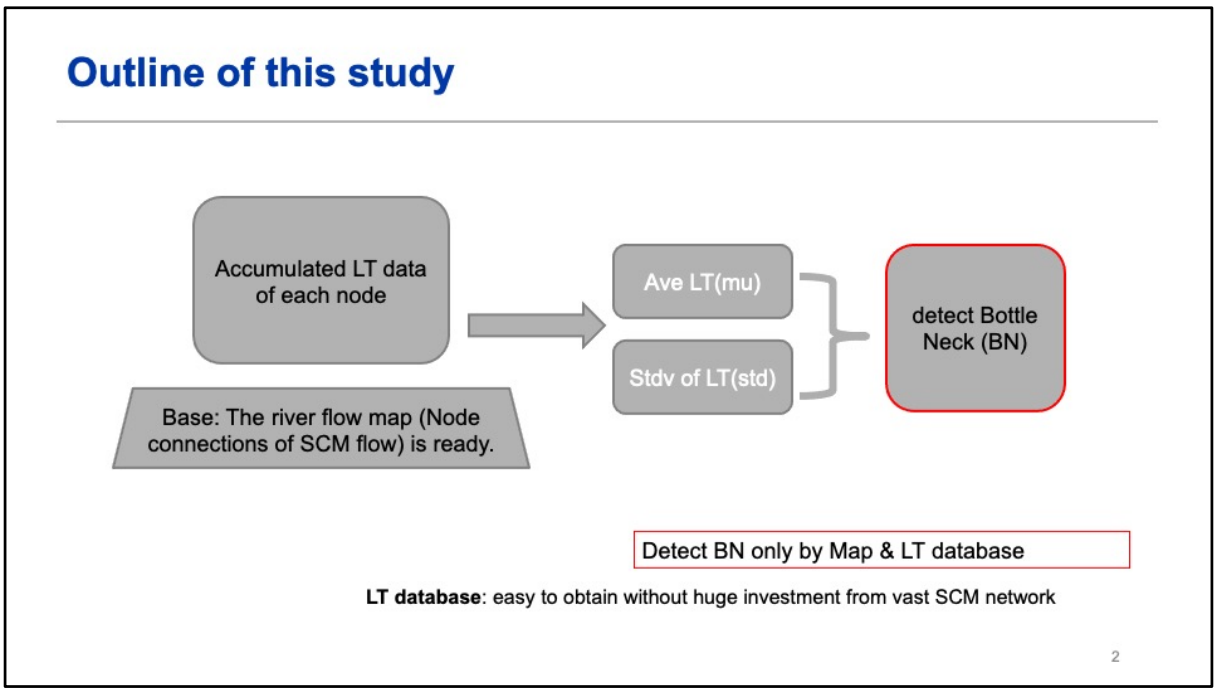
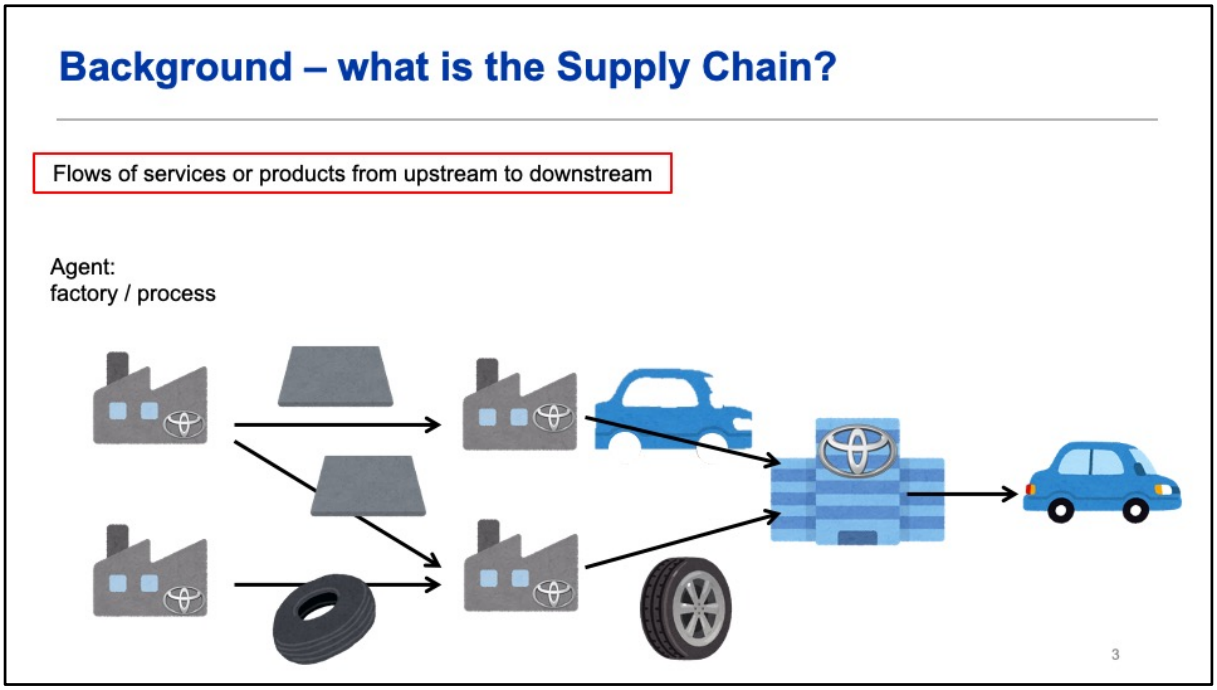
2021/Dec/17

self introduction

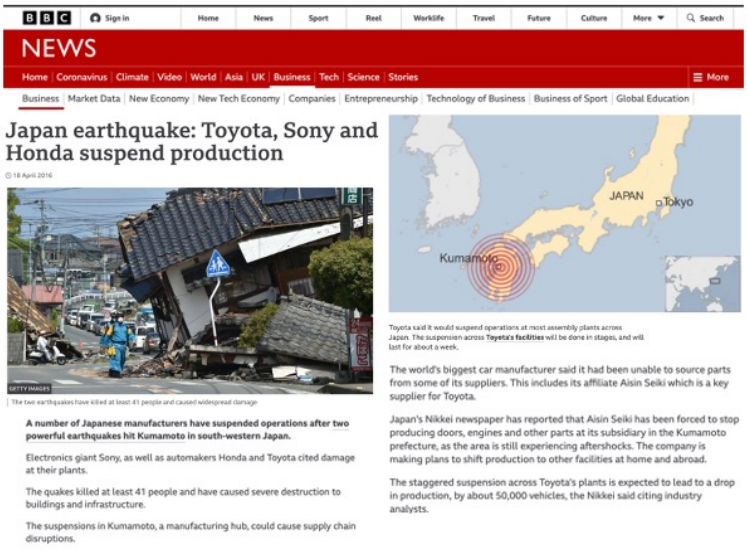


P2 : This is a research that can detect the location of the bottleneck among the vast SC network only if the accumulated Lead time database is available upon the SC network map using simulator.



P3 : First of all, what is SC? It is the flow of the goods or services through the different agents from upstream to downstream that will be delivered to the consumers in the end. Each agent can be a factory or a process. After one node finished production, the component parts are shipped to the next factories and finally assembled to the end product.

Background – impact of production stoppage



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Japan earthquake: Toyota, Sony and Honda suspend production

18 April 2016

GETTY IMAGES

The two earthquakes have killed at least 41 people and caused widespread damage

A number of Japanese manufacturers have suspended operations after two powerful earthquakes hit Kumamoto in south-western Japan.

Electronics giant Sony, as well as automakers Honda and Toyota cited damage at their plants.

The quakes killed at least 41 people and have caused severe destruction to buildings and infrastructure.

The suspensions in Kumamoto, a manufacturing hub, could cause supply chain disruptions.

Toyota said it would suspend operations at most assembly plants across Japan. The suspension across **Toyota's facilities** will be done in stages, and will last for about a week.

The world's biggest car manufacturer said it had been unable to source parts from some of its suppliers. This includes its affiliate Aisin Seiki which is a key supplier for Toyota.

Japan's Nikkei newspaper has reported that Aisin Seiki has been forced to stop producing doors, engines and other parts at its subsidiary in the Kumamoto prefecture, as the area is still experiencing aftershocks. The company is making plans to shift production to other facilities at home and abroad.

The staggered suspension across Toyota's plants is expected to lead to a drop in production, by about 50,000 vehicles, the Nikkei said citing industry analysts.

Examples

1. Toyota 2007Jul20, 1.5days, total ¥53,5bil, Niigata earthquake
2. Samsung 2007Aug04, total $54,2mil, Seoul Elec blackout
3. Honda 2010Jun04, ¥2,6bil/day, total 13,6bil JPY Guangdong CN labor strike

SCM loss is huge even few days stoppage.

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P4・5・6・7・8：Once the flow of SC was stopped, enormous loss will be caused. Therefore all SC stakeholders tries to make the flow smoothly.

Background – example 1

トヨタ生産停止で損失５００億円超

新潟県中越沖地震によるトヨタの生産停止で、愛知県内の経済的損失は五百億円超ー。大垣共立銀行系シンクタンク、共立総合研究所（岐阜県大垣市）の江口忍主任研究員が十九日、トヨタ自動車の操業停止に伴う影響額の試算を明らかにした。

試算では、トヨタの生産ラインが一日止まると国内総生産（ＧＤＰ）に相当する愛知県の県内総生産（名目）は０・１%低下。一次部品メーカーを含む企業収益や従業員所得などで三百五十七億円の減少要因となる。

トヨタは今回、一・五日分の生産を停止するため、損失額は五百三十五億円程度に上る見通し。ただ、操業再開後の休日の生産振り替えなどで容易に取り戻せる影響規模という。

今回被災したリケンのように主要部品を担う部品メーカーは愛知県などに多く、江口研究員は「今後は東海地震を想定し、拠点を分散させる動きが強まるのではないか。東海経済にマイナスに働く可能性もある」と指摘している。

出典：2007年7月20日　中日新聞

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Background – example 2

REUTERS マーケット 外為 株式市場 ニュース 経済・政策 ワールド 企業・産業 オピニオン ライフ

Investing | 2007年 08月 4日 00:07 JST

UPDATE2: サムスン<005930.KS>の半導体工場で一部製造ライン停止、供給ひっ迫の恐れ

［ソウル　3日　ロイター］　韓国のサムスン電子(005930.KS)は3日、ソウル近郊の半導体製造工場で発生した停電の影響で、6製造ラインの稼動を停止したことを明らかにした。半導体の供給ひっ迫や価格上昇観測が広がっている。

サムスンは、稼動停止に伴う損失が５００億ウォン（５４１９万ドル）を上回ることはない見通しとした。

ただ、アナリストはさらなる損失額を見込んでおり、一部は、同社のＮＡＮＤ型フラッシュメモリー（電気的に一括消去・再書き込み可能なメモリー）製造量の１カ月分に相当する損失につながる可能性があると指摘した。調査会社ｉＳｕｐｐｌｉによると、第１・四半期末時点でサムスンの世界のＮＡＮＤフラッシュメモリー市場でのシェアは４４％。

出典：Reuters 2007/08/04

Background – example 3

Honda：広州工場のストライキで10億元の損失を計上

| トラックバック（0） |

2010年6月4日、Honda自動車傘下の広州Honda工場のストライキが終了、工場が通常稼働状態に戻ることが明らかになった。

広州工場では、賃金問題で不満を持つ従業員がストライキを行っていた。現時点までのHonda自動車の損失は10億元（約136億円）以上と見られている。

（China　Press　2010：KM）

（06/04 12:25）

出典：China Press 2010/06/04

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ホンダ、ストライキによる損失額は1日26億円超に

出典：Searchina 2010/05/29

サーチナ 2010年5月29日 13時03分 (2010年6月1日 00時12分 更新)

ツイート いいね！ 0

ホンダ中国の広報担当である朱林傑氏は27日、ホンダの部品工場で発生している従業員のストライキにより、同社の中国にある組立工場4カ所がすべて稼動停止となっていることを明らかにした。工場は3社の傘下で、うち2社は合弁会社、1社はホンダの独資会社だ。ホンダは27日の時点でまだ対応策を発表していない。中国網（チャイナネット）日本語版が伝えた。

中国の従業員との話し合いが進まず、部品工場は稼動停止となり、ホンダの完成車の製造にも遅れが出ている。

ホンダ中国と2社の合弁会社の責任者は27日、『毎日経済新聞』に稼動停止となっていることを認め、すでに部品工場1カ所と組立工場4カ所が稼動を停止していることを明らかにした。CR－Vやスピリア、シビックなど中国で販売されている7車種に影響が及ぶと見られている。

また、ホンダの合弁会社が今週初めから稼動停止となっているのに続き、工場側は従業員に休暇を与え、業務再開時期もはっきりしていないという。東風ホンダの劉洪副社長は、生産工程を調整し、一部生産ラインの従業員に休暇を与え、別の従業員が作業を行うなどの措置を採っており、まもなく稼動再開できるとしている。

■生産高ベースで1日当たり2．4億元の損失

稼動停止は5カ所の工場にどれほどの損失をもたらしたのだろうか。これについて、業界関係者はデータをもとに分析を行った。

2社の合弁会社の4月の販売データによると、2社の1日当たりの生産台数は1800台で、それに独資会社を加えれば生産台数は約2000台になる。…

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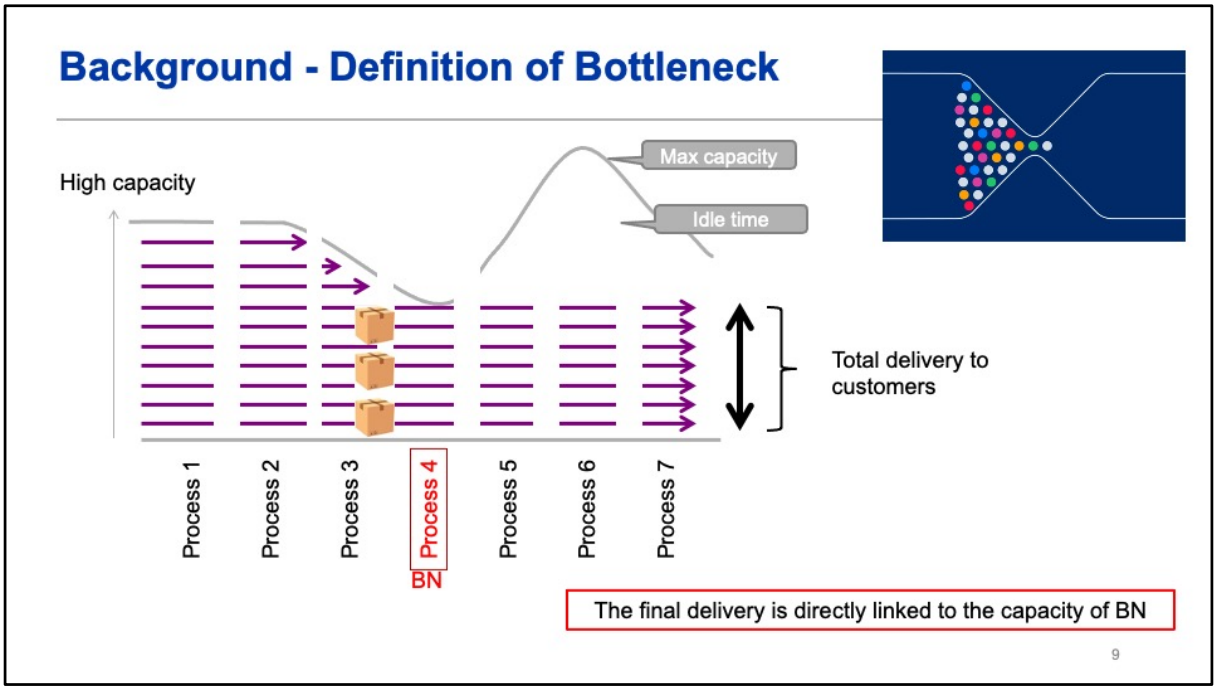
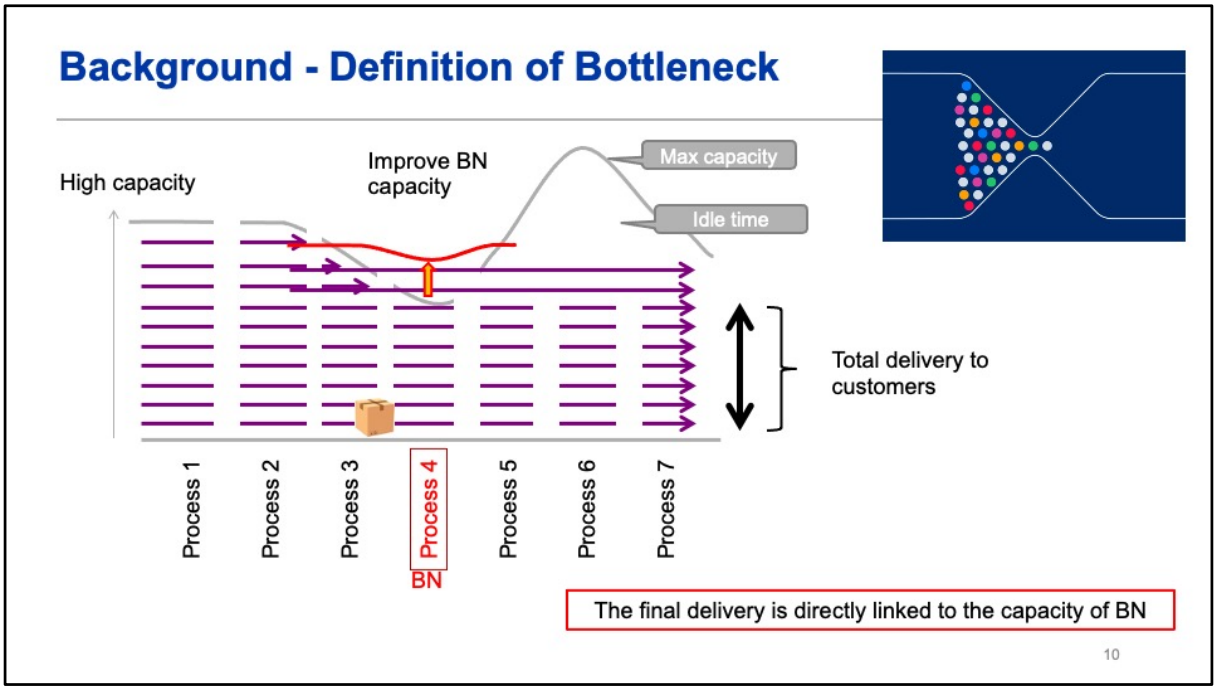
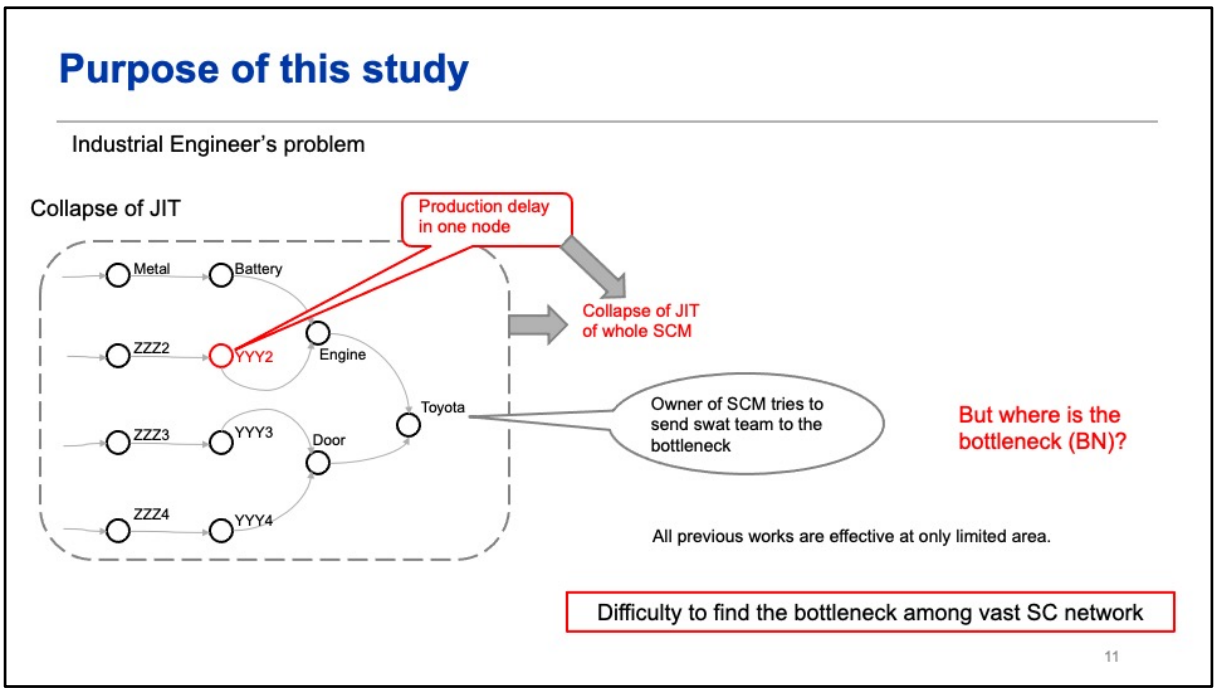


P9 : Not only the serious stoppage, but also the assembly line slowdowns occur frequently. To expedite the production to recover the delay, the first place you need to tackle is the BN. In the graph of the production capacities in the serial consecutive processes in the same line, the process of lowest capacity is called as the BN.

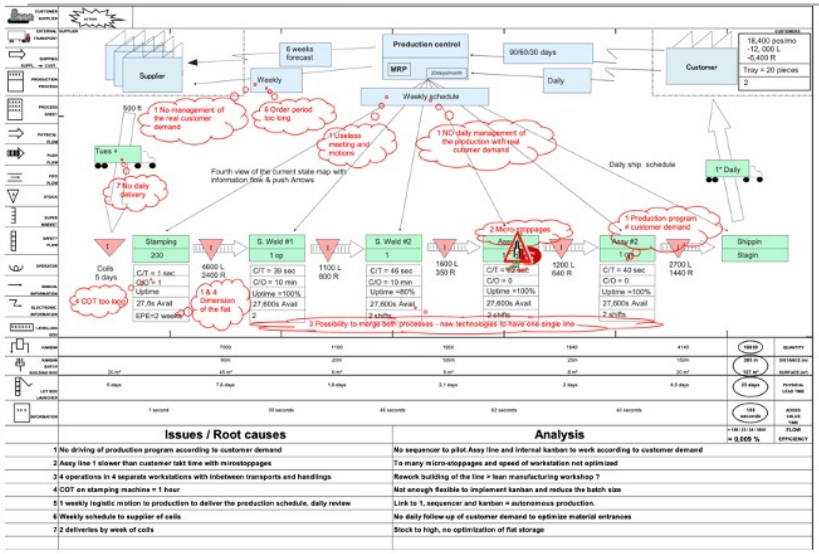


P9 :
One remarkable point here is the stacked cue of the WIP in front of the BN. Once the capacity of BN is reinforced, the CUE will be decreased. Meanwhile, about the utilization rate, the process with lower capability is always running, but on the other hand, the strong processes sometimes stay idle with waiting for the arrival of work from the upstream.



10 : The balance of the capability among network is necessary for the whole SC network. Once the delay occurred at one factory of the suppliers, the owner of the SC tries to send the swat team even for the outsider supplier. But the point is the location of the BN among the vast network.

Existing method: Value Stream Analysis



Standard method among manufacturing industry

- Need skills to draw
- Time and efforts consuming
- Static snapshot only
- Drawable area is limited
- Difficult for complicated branching

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P11 : This is the common method used in the manufacturing industry that is called as VSA to visualize the balance. But it is time consuming to draw with waking around the factory shop floor with stopwatch. It just draws the static snapshot status of the production and it is not dynamic. It is not good at drawing the river Amazon kind of vastly branched complicated network.

Related works

ROSER, Christoph; NAKANO, Masaru; TANAKA, Minoru. **A practical bottleneck detection method.** In: *Proceeding of the 2001 Winter Simulation Conference (Cat. No. 01CH37304)*. IEEE, 2001. p. 949-953.

ROSER, Christoph; NAKANO, Masaru; TANAKA, Minoru. **Comparison of bottleneck detection methods for AGV systems.** In: *Winter Simulation Conference*. 2003. p. 1192-1198.

LI, Lin, et al. **Bottleneck detection of manufacturing systems using data driven method.** In: *2007 IEEE international symposium on assembly and manufacturing*. IEEE, 2007. p. 76-81.

MALKOWSKI, Simon, et al. **Bottleneck detection using statistical intervention analysis.** In: *International Workshop on Distributed Systems: Operations and Management*. Springer, Berlin, Heidelberg, 2007. p. 122-134.

LAW, Averill M.; MCCOMAS, Michael G. **Simulation of manufacturing systems.** In: *Proceedings of the 19th conference on Winter simulation*. 1987. p. 631-643.

BODNER, Douglas A.; MCGINNIS, Leon F. **A structured approach to simulation modeling of manufacturing systems.** In: *IIE Annual Conference. Proceedings*. Institute of Industrial and Systems Engineers (IISE), 2002. p. 1.

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P12 : There has been many researches about SC to find the BN.

Related works – Method 1: WIP Cue length

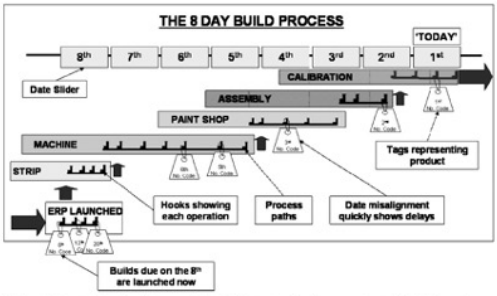

Figure 1. The visual control board used to communicate ERP output to shop floor operators to facilitate through process flo

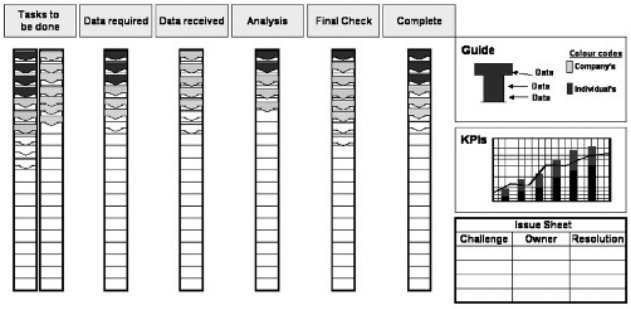

Figure 2. Schematic of the Airbus Aircraft Maintenance Manual process control board.

TAYLOR, T. A. A. S. Application of lean visual process management tools. *Production Planning and Control*, 17.1: 77-86.

- Kanban JIT system enable us to visually find the CUE size before BN.
- Risk of noise by dead stocks.
- Difficult to enhance the scope to suppliers that have different production systems.

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P13 : One remarkable predecessor research finds the BN by stacked CUE WIP. This method works especially at the JIT production system that operates by the Kanban cards. However, the downside is there may be the noises of dead-stocks inmixed in the cue. Even there seems a lot of WIP cues but in fact majority of them might be the works that is not ordered by the customers.

Related works – Method 2: Utilization rate

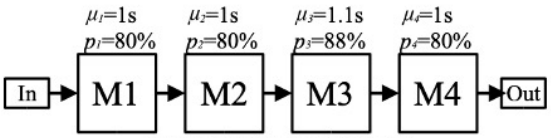

Figure 4: Flow Shop Layout

Table 2: Flow Shop Simulation Results

Machine	Utilization	%Sole	%Shifting	%Sum
M1	80.1%	12.67%	20.43%	33.1%
M2	80.2%	6.73%	15.93%	22.7%
M3	88.0%	32.54%	29.27%	61.8%
M4	80.0%	7.25%	15.23%	22.5%
Shiftiness Measure β		0.59	0.84	0.74

ROSER, Christoph; NAKANO, Masaru; TANAKA, Minoru. Shifting bottleneck detection. In: *Proceedings of the Winter Simulation Conference*. IEEE, 2002. p. 1079-1086.

- Magnitude / rank order is easy to tell.
- Possible only within limited area that equipped the util counter sensor.
- Not applicable at complexed line.

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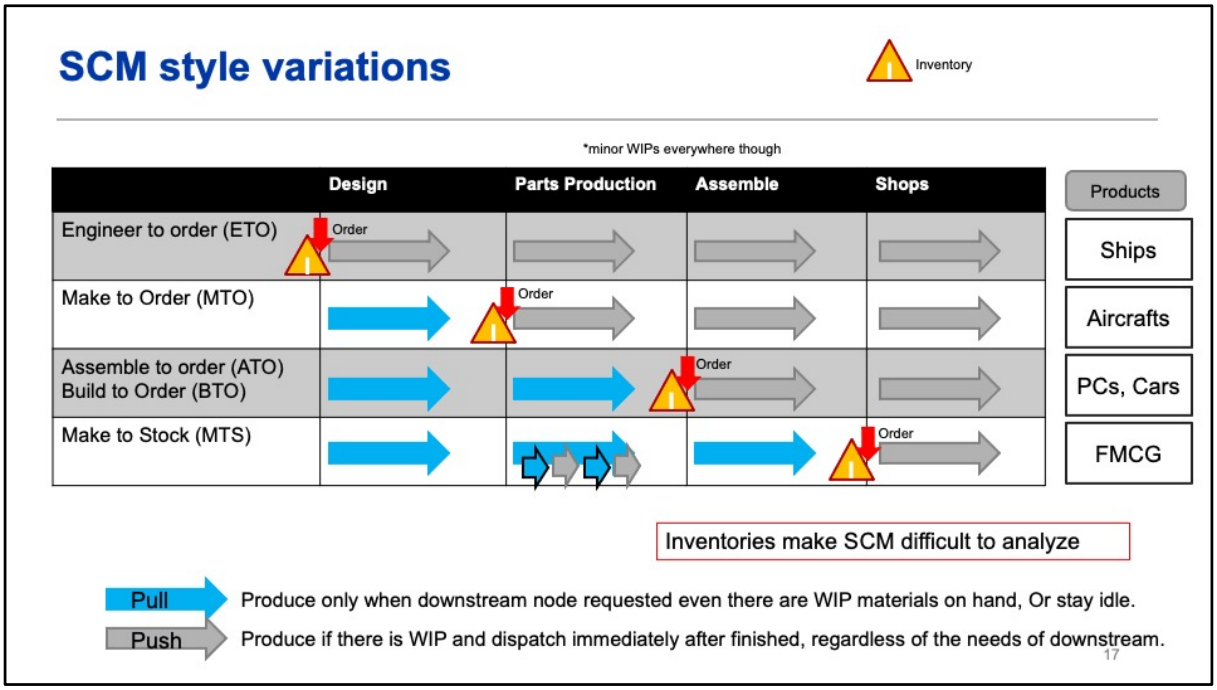
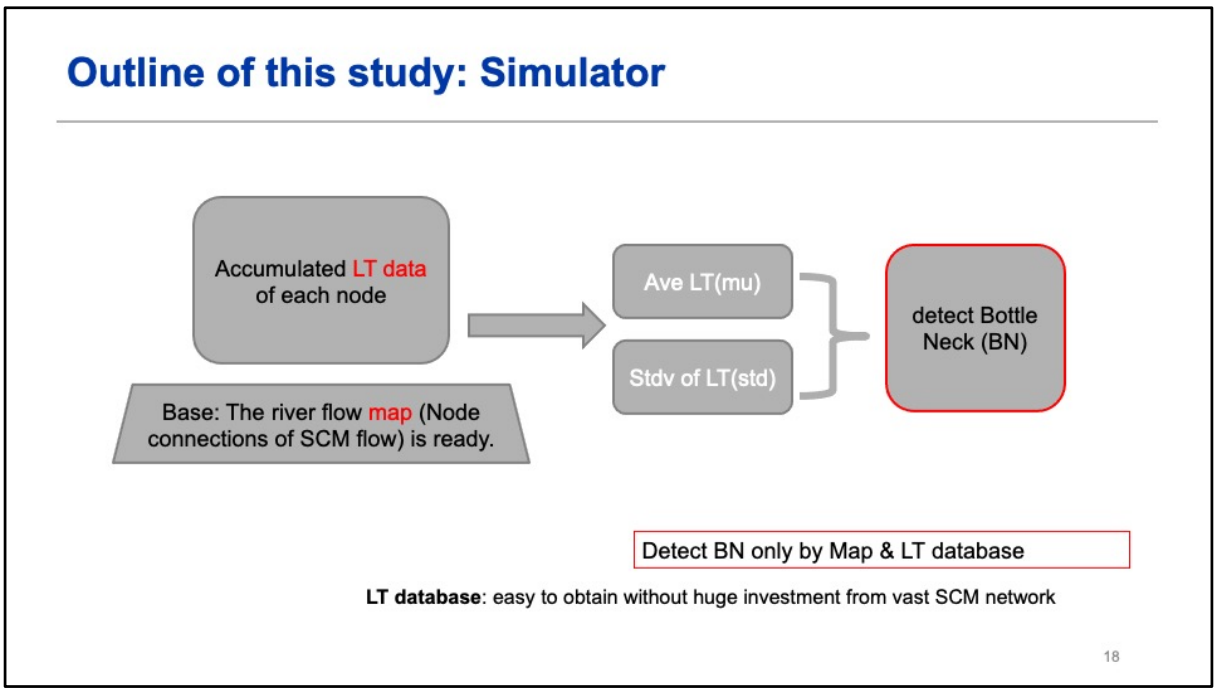
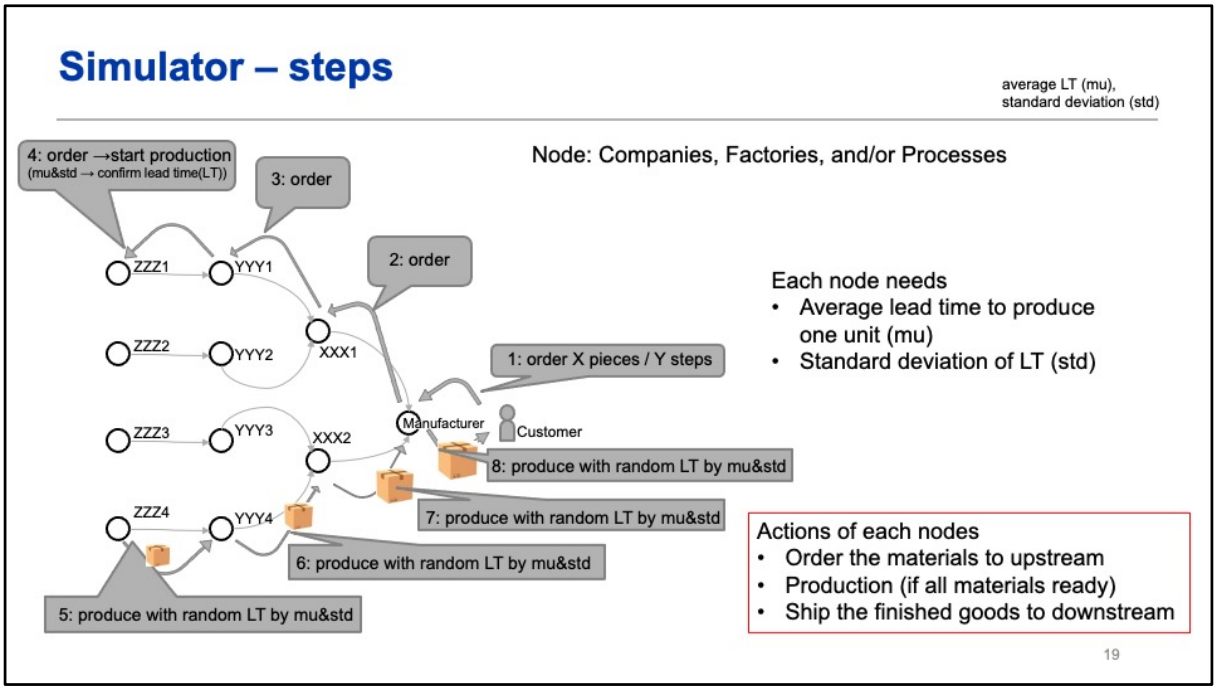
P14 : The other method to detect the BN is the utilization ratios of each nodes to see the balance between the processes. This is very clear to compare. However the policies such as “push” or “pull” of the production system should be same among the scope of comparison.



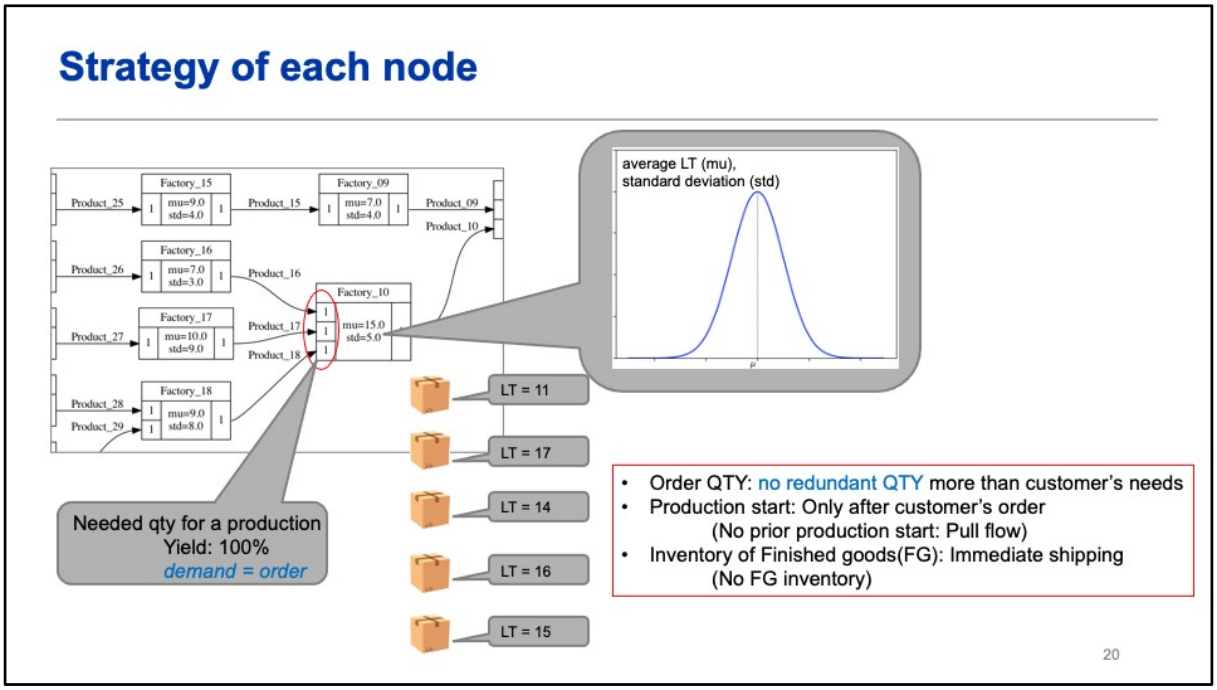
P16：Make to order, or preemptive push production, depends on the character of the product basically. However, even among the same network producing the same product, there may be the factories with different production policies. In such cases, we can't compare the utilization rates in the same manner between the factory that produce without orders and the factory stay idle if no orders. Therefore, in both method of the cue stack and the utilization rate, it is very difficult to draw the wide scope SC network in the same picture.



P17：Therefore, this research proposes the new method that enable to find BN among the vast SC network in the same picture with using the map and the accumulated LT data.

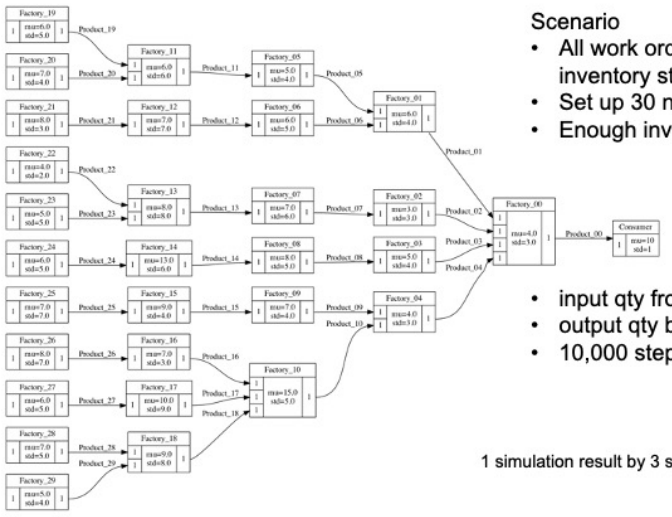


P18 : This is how the simulator runs. the map is created by connecting the nodes. This node can be one whole factory or can be one process among the production line. The BOM (Bill of Material) information is contained in this map. The info is like how many parts input is needed for one certain node to produce certain qty of the finished goods. The sequence of the process is 1: check the order from downstream, 2: finish the production, 3: dispatch the finished goods if there are, 4: if there were orders and also the input materials are ready, start the next production.
This sequence finishes at 10,000 step.
Each node orders the materials to upstream, produce from the arrived materials, and ship the finished goods to downstream. Additionally to the map, the needed KPI for the nodes are average LT and its standard deviation.



P19：The needed LT steps to finish production is defined randomly under gaussian distribution from the preset Mu and Std. Please note that all input materials should be ready to start the production, otherwise the node stay idle.

Target scenario



Scenario
- All work orders are based on the customer orders (no inventory stand-by for future orders)
- Set up 30 nodes at supply side and one customer node
- Enough inventory at input side of the first node (tier-4)

- input qty from one node: 1
- output qty by one production lot: 1
- 10,000 step

1 simulation result by 3 seconds for 30 nodes map

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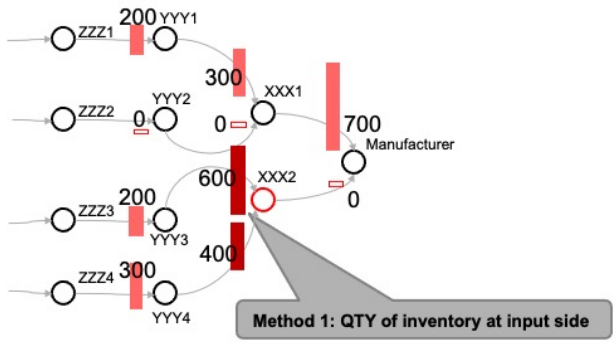
P20：In this experiment, 30 nodes are connected up to Tier4 for one customer to create the map. All the needed qty of the materials and the qty of the finished goods by one production is 1 this time. The defect rate is zero. Only one kind of the end-product is produced from this network. The finished goods are immediately dispatched to downstream after the production and there are no finished goods inventory stored. The material orders are only for the needed qty enough for the orders and nodes will not order redundant qty of the materials.
All the order actions are triggered by the orders from the customer, that is called as pull production policy. It means, no preemptive production. At the beginning location of the flow, the inventories are prepared adequately enough.
With this scenario, I run the simulation 100 times.

Detecting the bottleneck: Method 1 WIP cue size



All of input side: Not zero
Max qty is No.1 BN
* first node not applicable

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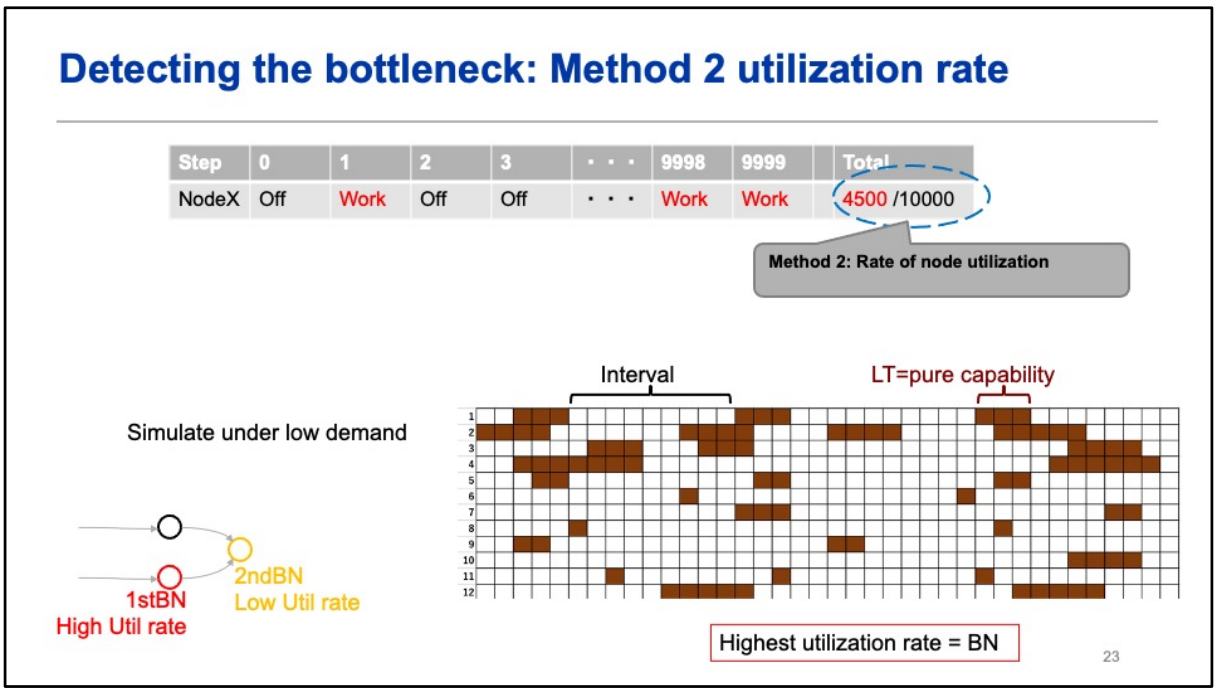
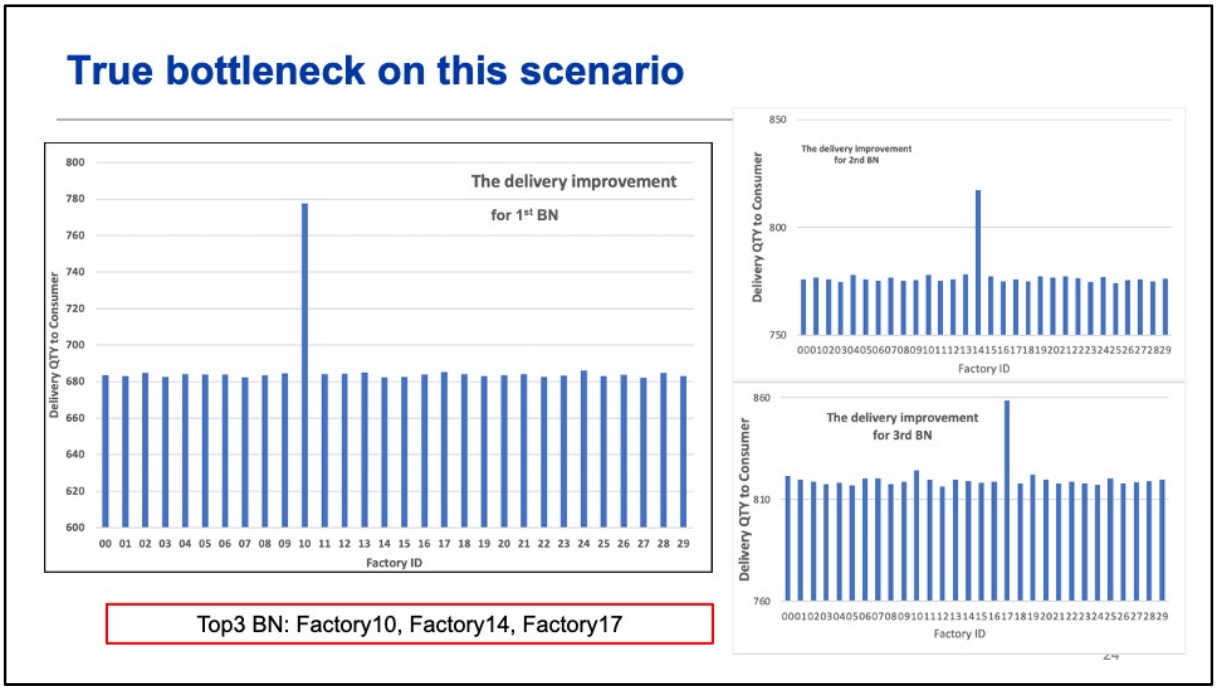
P21：Method 1. BN is detected by the stacked up WIP cue qty. The red rectangle in this illustration shows the cue WIP qty. If the cue is huge, the capability of the node is lower than the upstream. Therefore, we defined the node with the highest cue as BN. Please note the node is excluded from the BN candidates list if one or some of the cue WIP was zero, because the delay of this node production is not by the lack of the capacity but by the delay of the arrival of materials from upstream.



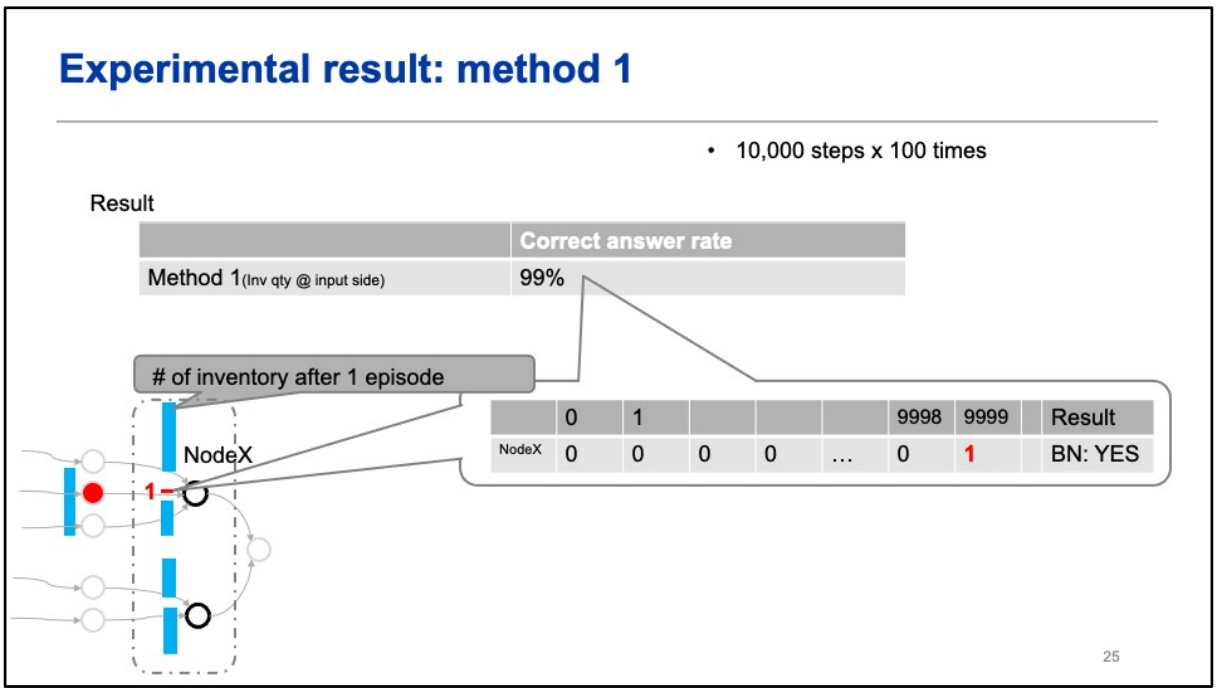
P22 : The method 2: the utilization rate is defined by the number of steps with the On status among the total steps. If many nodes were running at 100% utilization rate, simulator lower the customer demand without changing the specs of the production network. If the node is running at high utilization rate, it means that node must be the BN because the production capability is low.

Here we could avoid the shadowing effect of BN. If the 2nd BN was located right after the 1st BN, the util rate of 2nd BN might be lower than the reality because of the slow arrival of the works from upstream. Therefore, this simulator is effective to lower the demand. Then we can directly see the LT length without interactions between the orders to see the real capability.

The list of the nodes sorted from the higher utilization rate is defined as the BN degree.



P23 : We prepared the answer data beforehand of the experiment. The definition of the BN is the node of lowest capability, so I improved the performances of each node and monitored the final delivery qty to customer. There are 30 nodes here, and I improved both of mu and std for 20% for only one node for 30 times. The result of 20% improvement on factory No.00 is this. The result of Factory No.01 improvement is this. Among all improvements shows same result, only Factory No.10 delivered more products after it's improvement. Therefore, the first BN is No.10.
After the 20% improvement on No.10, I improved 20% again for each node. Then, it turned out that the 2nd BN is No.14. After the 20% improvement on No.14, again I improved for 20% for each. Then, we got No.17 factory as the 3rd BN. We use this as the correct answer data.



P24 : We deployed Method 1 research. We run the experiment up to 10,000 steps for 100 times, we got Node No.10 as the BN, 99 times among 100. We scrutinized the failure 1 case, then found out that this node had almost always no wip cue at one of the input inventory therefore this node should not be listed as the BN candidate. However unluckily the WIP was arrived at the last step and this node was not counted as zero cue WIP.

Experimental result: method 2

- 10,000 steps x 100 times

行ラベル	30459.csv	30519.csv	30539.csv	30559.csv	30619.csv	30638.csv	30658.csv	30717.csv	30737.csv	30756.csv	30816.csv	30835.csv	30854.csv	30914.csv	30933.csv	30952.csv	31012.csv	'-231031.csv	'-231050.csv	'-231110.csv	'-
Factory_00	0.215	0.2211	0.2231	0.2176	0.2181	0.2281	0.2216	0.2249	0.2237	0.2247	0.2283	0.2181	0.2327	0.228	0.2238	0.2293	0.2206	0.221	0.23	0.2168	
Factory_01	0.3256	0.3266	0.3227	0.3287	0.3267	0.3152	0.3159	0.3137	0.3253	0.3163	0.332	0.3087	0.3294	0.346	0.3084	0.323	0.3225	0.3226	0.3148	0.3216	
Factory_02	0.1903	0.196	0.188	0.1898	0.1976	0.1936	0.1938	0.1945	0.1847	0.1957	0.1947	0.195	0.1923	0.193	0.1872	0.1968	0.1862	0.1943	0.1863	0.1953	
Factory_03	0.2843	0.3003	0.286	0.3013	0.3021	0.2879	0.2911	0.2919	0.3025	0.2872	0.2863	0.2916	0.2964	0.2955	0.301	0.2964	0.2832	0.2827	0.28	0.302	
Factory_04	0.2198	0.2271	0.2328	0.2147	0.2255	0.2258	0.2307	0.2196	0.2253	0.2245	0.2229	0.2315	0.2294	0.2228	0.2229	0.2257	0.2229	0.2176	0.221	0.2312	
Factory_05	0.2942	0.2967	0.2979	0.2831	0.287	0.2858	0.2914	0.2808	0.288	0.3046	0.2836	0.3066	0.2943	0.2915	0.3005	0.3029	0.294	0.2928	0.2988	0.2907	
Factory_06	0.355	0.3637	0.3583	0.3591	0.3609	0.3618	0.3641	0.3421	0.35	0.3598	0.3723	0.3471	0.3538	0.3636	0.3613	0.3532	0.3577	0.3685	0.3273	0.3547	
Factory_07	0.4318	0.409	0.414	0.4277	0.4309	0.4304	0.4218	0.4215	0.4302	0.4228	0.4195	0.4159	0.4201	0.4269	0.4327	0.4384	0.4403	0.4447	0.4188	0.4308	
Factory_08	0.4383	0.4154	0.4277	0.4353	0.4178	0.4132	0.4217	0.4218	0.414	0.4362	0.4257	0.4183	0.4438	0.4286	0.4349	0.4263	0.4142	0.4319	0.4332	0.4427	
Factory_09	0.3661	0.3608	0.3536	0.365	0.3554	0.3629	0.3619	0.3462	0.3653	0.3629	0.3684	0.3567	0.353	0.3559	0.3727	0.3655	0.3534	0.3615	0.3651	0.3657	
Factory_10	0.7528	0.7499	0.7622	0.7593	0.741	0.7317	0.7494	0.7507	0.74	0.7641	0.7435	0.7584	0.7362	0.7547	0.7535	0.7405	0.7419	0.7369	0.7364	0.7391	No.1(100/100)
Factory_11	0.3999	0.385	0.3773	0.3843	0.3765	0.399	0.4057	0.4091	0.408	0.3941	0.3883	0.3985	0.3895	0.3824	0.3792	0.401	0.3907	0.3815	0.3861	0.3927	
Factory_12	0.4743	0.471	0.4416	0.4647	0.4597	0.4575	0.4502	0.48	0.4452	0.4634	0.4675	0.4512	0.4722	0.4669	0.4474	0.4425	0.4499	0.4647	0.4624	0.4552	
Factory_13	0.5142	0.5242	0.5088	0.5282	0.5163	0.5612	0.5294	0.5227	0.5399	0.547	0.5189	0.5299	0.5516	0.5026	0.514	0.5432	0.5335	0.5158	0.5165	0.5182	
Factory_14	0.686	0.6563	0.6508	0.6658	0.6454	0.6559	0.6574	0.6246	0.645	0.6774	0.6429	0.6428	0.6523	0.6755	0.6506	0.6522	0.6372	0.654	0.6659	0.665	No.2(95/100)
Factory_15	0.4561	0.4447	0.4527	0.4445	0.4593	0.4252	0.4412	0.4516	0.4486	0.4484	0.4482	0.4374	0.4224	0.4498	0.4513	0.4725	0.4564	0.4502	0.4473	0.4559	
Factory_16	0.3313	0.3396	0.34	0.3326	0.3436	0.3479	0.3431	0.3393	0.3389	0.3436	0.3446	0.3428	0.342	0.3477	0.3377	0.3412	0.3404	0.3547	0.3436	0.3446	
Factory_17	0.618	0.6369	0.6343	0.6249	0.6355	0.6011	0.6266	0.6457	0.6403	0.6186	0.6436	0.6209	0.6034	0.5989	0.6098	0.6192	0.6175	0.6405	0.6515	0.6192	No.3(95/100)
Factory_18	0.5287	0.5469	0.575	0.5597	0.5537	0.5679	0.5555	0.5563	0.5443	0.5505	0.5647	0.5533	0.5637	0.5742	0.5547	0.5409	0.5351	0.5587	0.558	0.5579	
Factory_19	0.3603	0.3532	0.3659	0.364	0.3474	0.3717	0.3532	0.3676	0.354	0.3697	0.3545	0.3525	0.3579	0.3499	0.3452	0.3503	0.3509	0.3447	0.3644	0.3484	
Factory_20	0.381	0.3564	0.3561	0.3517	0.3654	0.3639	0.3613	0.3618	0.3639	0.363	0.3773	0.3787	0.3743	0.3587	0.3636	0.3672	0.3634	0.3647	0.3594	0.3566	
Factory_21	0.4007	0.3793	0.378	0.3881	0.3825	0.3986	0.3874	0.3832	0.4019	0.3884	0.3964	0.3825	0.3871	0.3879	0.4034	0.3898	0.3883	0.3878	0.3923	0.3871	
Factory_22	0.188	0.196	0.1937	0.1996	0.1982	0.1944	0.1939	0.1979	0.1888	0.1902	0.1965	0.1905	0.2029	0.1918	0.1944	0.1944	0.1934	0.1984	0.2	0.2	
Factory_23	0.3217	0.3319	0.3245	0.3365	0.3295	0.3317	0.3297	0.3263	0.3278	0.3304	0.3031	0.3209	0.3231	0.3149	0.3294	0.3307	0.3256	0.3187	0.3159	0.3464	
Factory_24	0.3508	0.3617	0.3657	0.3653	0.3697	0.3698	0.3685	0.361	0.3613	0.3478	0.3623	0.359	0.3652	0.3619	0.35	0.3674	0.3515	0.3749	0.3564	0.339	→ Ave
Factory_25	0.4363	0.4643	0.4455	0.454	0.4564	0.4651	0.4545	0.4477	0.4665	0.4545	0.464	0.4639	0.4665	0.4487	0.4582	0.4708	0.4592	0.4527	0.4516	0.4646	Next page
Factory_26	0.488	0.4998	0.5007	0.4822	0.4779	0.4939	0.481	0.4954	0.5012	0.5048	0.4913	0.4843	0.5074	0.4676	0.4903	0.5257	0.4849	0.4808	0.4859	0.4713	
Factory_27	0.3521	0.365	0.3483	0.3633	0.3468	0.3625	0.3621	0.3384	0.3491	0.3698	0.3657	0.3616	0.3593	0.3443	0.3487	0.3504	0.3628	0.3638	0.3556	0.3541	
Factory_28	0.3766	0.3922	0.3825	0.393	0.3901	0.3794	0.3677	0.3833	0.3847	0.3782	0.3971	0.3989	0.3893	0.3892	0.3795	0.3823	0.4058	0.3999	0.3944	0.3948	
Factory_29	0.307	0.2892	0.3008	0.3031	0.2985	0.298	0.29	0.2865	0.289	0.2981	0.2965	0.2888	0.2878	0.2937	0.2966	0.2815	0.2934	0.2912	0.2906	0.2948	

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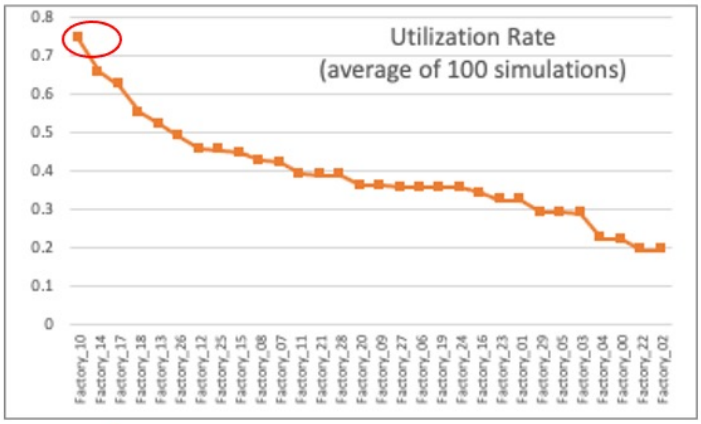
P25：This is the result of Method 2. We got Node 10 as BN 100 times among 100 experiments. 2nd BN was No.14 node, 95 times among 100 experiments. 3rd BN was No.17, 95 times among 100 experiments.

Experimental result: method 2



Proposed BN detection method can show the ranking: BN degree

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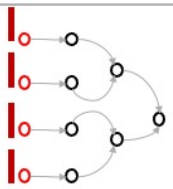
P26：This is the graph showing the average utilization rate among 100 times for all 30 nodes. I name this rank order as “BN degree”.

Discussion

Method 1: stack WIP cue
- Weak point: It can't detect the BN if it is at the top tier.
- Weak point: Need to make the criteria more sophisticated.
  - ➢ Same qty of inventory does not mean same magnitude of BN
    Need the BOM info: equivalent to how many cars?



Method 2: Utilization rate
- Good point: BN degree : how close each node is to being a bottleneck
- Good point: It can detect the BN even located at top tier
  - ➢ Double BNs is also possible to detect

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P27 : Summary. Method 1 uses the WIP cue, and this method can't detect the BN if it is located at the top of the flow because we prepared adequate amount of the raw materials there. Also, this philosophy to compare the WIP should be sophisticated considering the BOM information, as we detected wrong node as BN one time. The impact of one WIP of one engine delay is more than the one bolt.

Method 2 has several good points like BN degree, top node also included for the comparison. Also, the double BN is possible to detect even it is not possible for the method that used to find the "correct answer data".

Conclusion

- Simulator had been developed.

  Regardless of the differences of push or pull philosophy,
  only if the LT database was available, BN is detectable.
  Pure Util rate is detectable even right after the BN.

- New BN detection method is proposed

  LT is first data to obtain by digitalization. This would be
  one of the easiest method to visualize BN in the real world.

- This method did work.

  1. Answer data was detected for 1st, 2nd and 3rd BN.
  2. Both two methods: Cue stack/Utilization rate detected BN correctly.

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P28 : As the conclusion, 1: Simulator was developed.
2: Useful method to find BN was proposed by LT.
3: Validated that this method does work.

Future work plan

- Variation of the maps
- Yield
- Product mix
- Negotiation

Accumulated LT data of each node

Yield data of each node

Base: The river flow map
(Node connections of SCM flow) is ready.

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Thank you for your listening
any questions?

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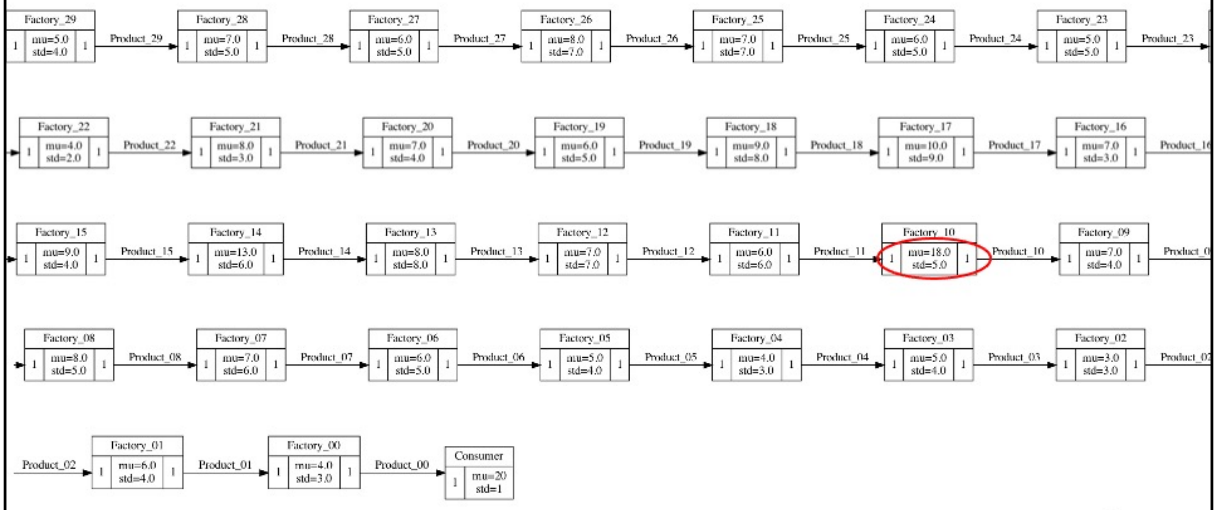
Back data

Future plan: 2nd map



Experimental result:

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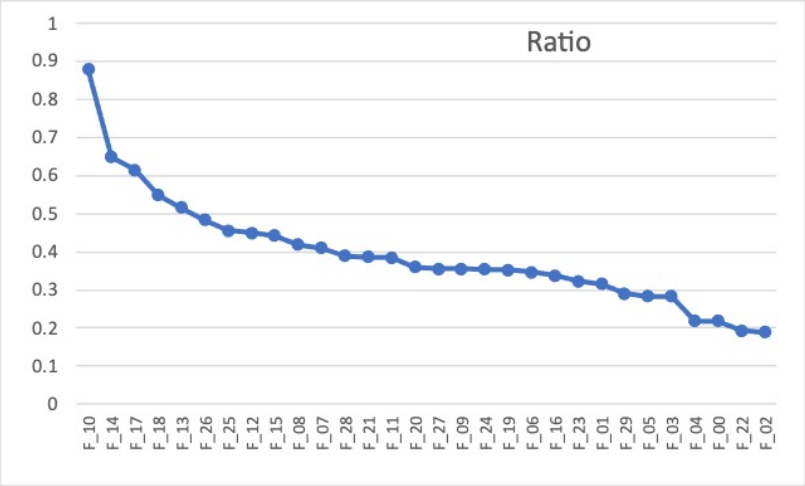
Experimental result: method 2



稼働率によるBN検知

10番工場を正しく検知

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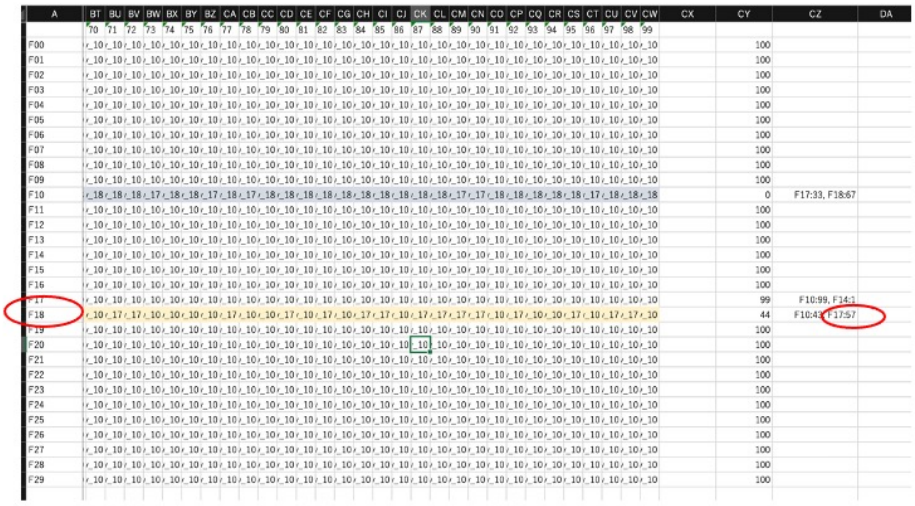
Experimental result: method 1



A	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY	CZ	DA
	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99				
F00	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		
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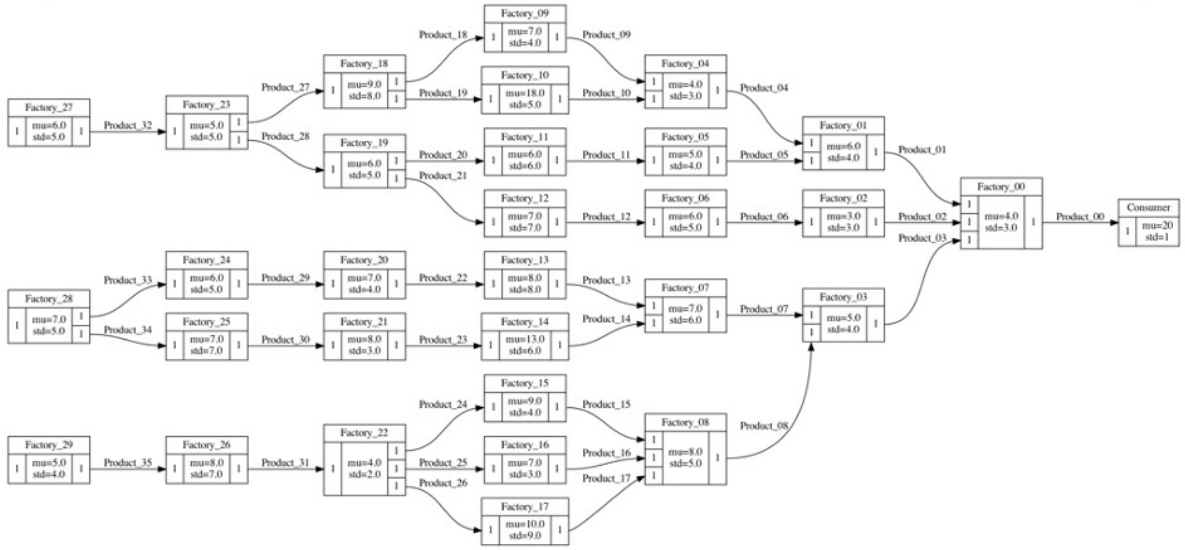
F25	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		
F26	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		
F27	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		
F28	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		
F29	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10	r,10		100		

Future plan: 3rd map



・ MCTSモンテカルロ探索　ルールベース　鉄棒回ったら得点高いですよ
ノウハウまで教えておく　　回れるようになる確率高いがノウハウ教える手間高し
シミュレーションから
(最適化問題ではない、最適とは言えない、前より良くなった、カイゼンしたとは言える。)

・ 強化学習は、鉄棒の回り方は教えないけど、偶然回った時に報酬を与えることで(教師データなし)
学んでゆく
ほったらかし　だが回数が長くかかる

・全体最適とはどのような状況を指しますか？
・各ノードはどのような行動を取りえますか？