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On the conditional decision procedure for high yield processes

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摘要

- CCC管制圖已經被證實有效應用在高產出製程上
- 然而此管制圖只使用單一數值來決定製程變化的發生，這將造成管制圖對偏移的不敏感
- 為提高此管制圖性能，將之前或現在觀測到的值進行條件機率的合併使用成決策規則
- 利用ARL進行績效評估，結果證實原管制圖是低估了ARL

目錄

1. Introduction

- 傳統的P管制圖不適合檢測高產出製程
- 由於高產出製程P值往往非常低，使的不良品難以偵測
- Goh (1987), Kaminsky, Benneyan, Davis, and Burke (1992), Glushkovsky (1994) and Xie and Goh (1995)也都推薦使用CCC管制圖進行高產出監控

- CCC捨棄傳統三倍標準差作為上下限，而使用機率界限
- Xie, Goh, and Kuralmani (2000b)發展一個最大ARL標準當製程是在穩定的水準下
- Kuralmani, Xie, Goh, and Gan (2002)建議有條件的決策規則來監控高產出製程
- Zhang, Govindaraju, Bebbington, and Lai (2004)建議使用不同的方法來進行控制或失去控制的ARLs

2. Conditional decision procedure

- Kuralmani et al. (2002)為提高此管制圖知性能，提出條件決策，將之前或現在觀測到的值進行條件機率的合併使用成決策規則
- 此時有兩種方式，第一種是照舊管制圖，第二種是以第S個觀測到的管制界線
- EX：S=1，必須有連續兩點超出管制界線，之後重新計算
- 由於使用了以往的資料，增加了此管制圖的敏感性

- 條件上下管制界線

$$\mathrm{UCL}_{\mathrm{cond}} = \frac{\mathrm{Ln}\left[\frac{(1-\delta)}{2}\right]}{\mathrm{Ln}\left[1-p\right]} \tag{1}$$

$$\mathrm{LCL}_{\mathrm{cond}} = \frac{\mathrm{Ln}\left[1-\frac{(1-\delta)}{2}\right]}{\mathrm{Ln}\left[1-p\right]}, \tag{2}$$

- 信賴水準

$$1-\alpha = \delta + (1-\delta)\delta^{s}. \tag{3}$$

- Kuralmani et al. (2002)進一步修改了最佳化最大ARL

$$\mathrm{UCL}_{\mathrm{opt}} = \frac{\mathrm{Ln}\,[(1-\delta)/2]\,\mathrm{Ln}\{\mathrm{Ln}\,[1-(1-\delta)/2]/\mathrm{Ln}\,[(1-\delta)/2]\}}{\mathrm{Ln}\,(1-p)\,\mathrm{Ln}\,\{[(1-\delta)/2]/[1-(1-\delta)/2]\}} \tag{4}$$

$$\mathrm{LCL}_{\mathrm{opt}} = \frac{\mathrm{Ln}\,[1-(1-\delta)/2]\,\mathrm{Ln}\,\{\mathrm{Ln}\,[1-(1-\delta)/2]/\mathrm{Ln}\,[(1-\delta)/2]\}}{\mathrm{Ln}\,(1-p)\,\mathrm{Ln}\,\{[(1-\delta)/2]/[1-(1-\delta)/2]\}}. \tag{5}$$

$$\begin{aligned} \beta &= p_{\mathrm{inc}} + p_{\mathrm{out}} \times \mathrm{pr}(\text{`previous } s \text{ or more runs in-control'}), \\ &= p_{\mathrm{inc}} + p_{\mathrm{out}} \frac{p_{\mathrm{inc}}^{s} p_{\mathrm{out}}}{1-p_{\mathrm{inc}}} = p_{\mathrm{inc}} + p_{\mathrm{inc}}^{s}(1-p_{\mathrm{inc}}), \end{aligned} \tag{6}$$

Pinc 為管制內機率

Pout為管制外機率

- Kuralmani et al. (2002)ARL評量績效

$$\mathrm{ARL_K} = \frac{1}{1 - p_{\mathrm{inc}} - p_{\mathrm{inc}}^{s}(1 - p_{\mathrm{inc}})} = \frac{1}{p_{\mathrm{out}}(1 - p_{\mathrm{inc}}^{s})}. \qquad (7)$$

- 上式低估了實際的ARL

3. Modified ARL equations

- ARL往往是假設為獨立且服從幾何分配，而在此是不需要使用上述假設，由於使用到過去資料

- 修正後ARL如下

$$\mathrm{ARL}_{\mathrm{Modified}} = \frac{2 - p^{s}_{\mathrm{inc}}}{p_{\mathrm{out}}(1 - p^{s}_{\mathrm{inc}})} \tag{8}$$

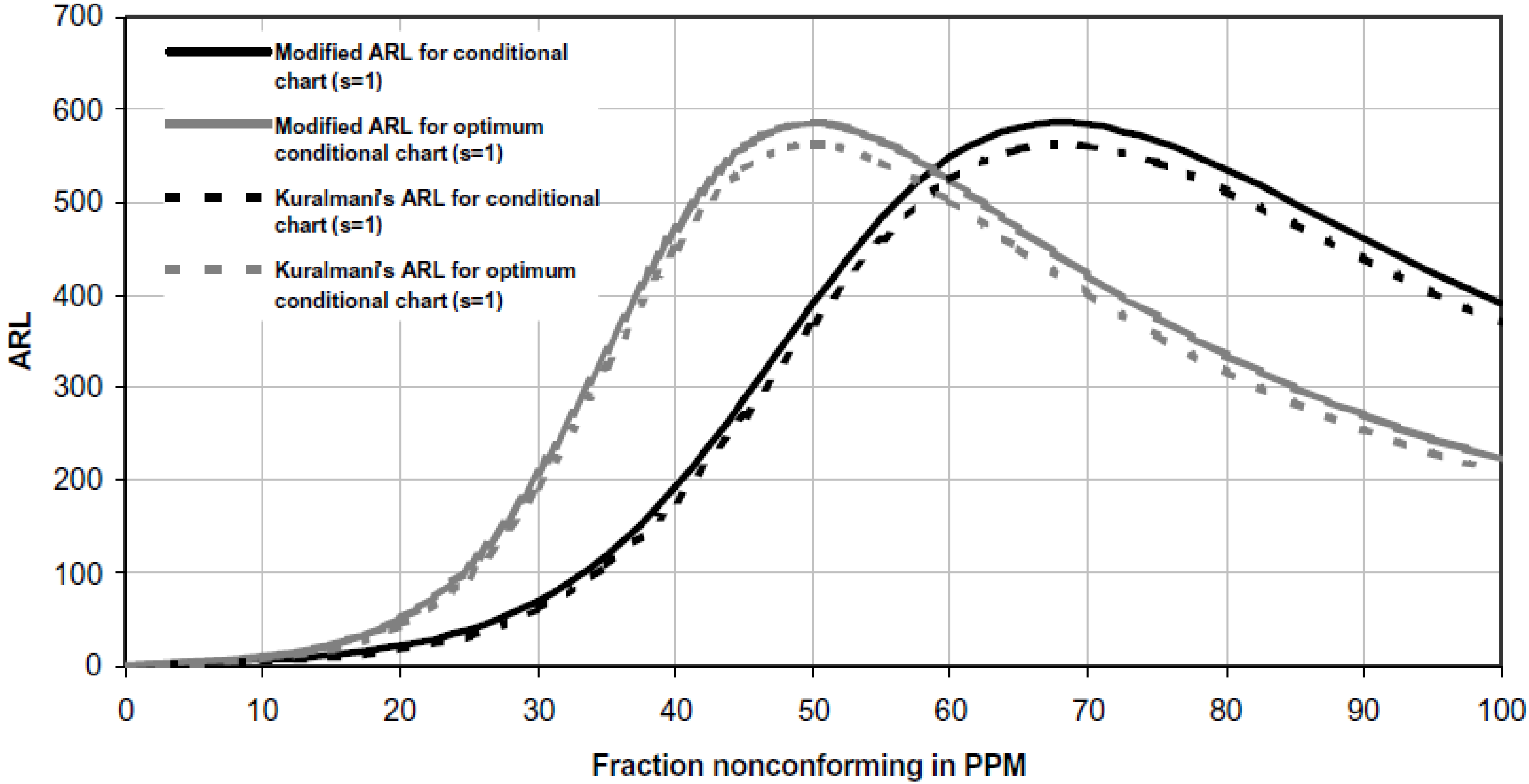

Fig. 1. ARL curves for $s = 1$ and $p = 50$ ppm.

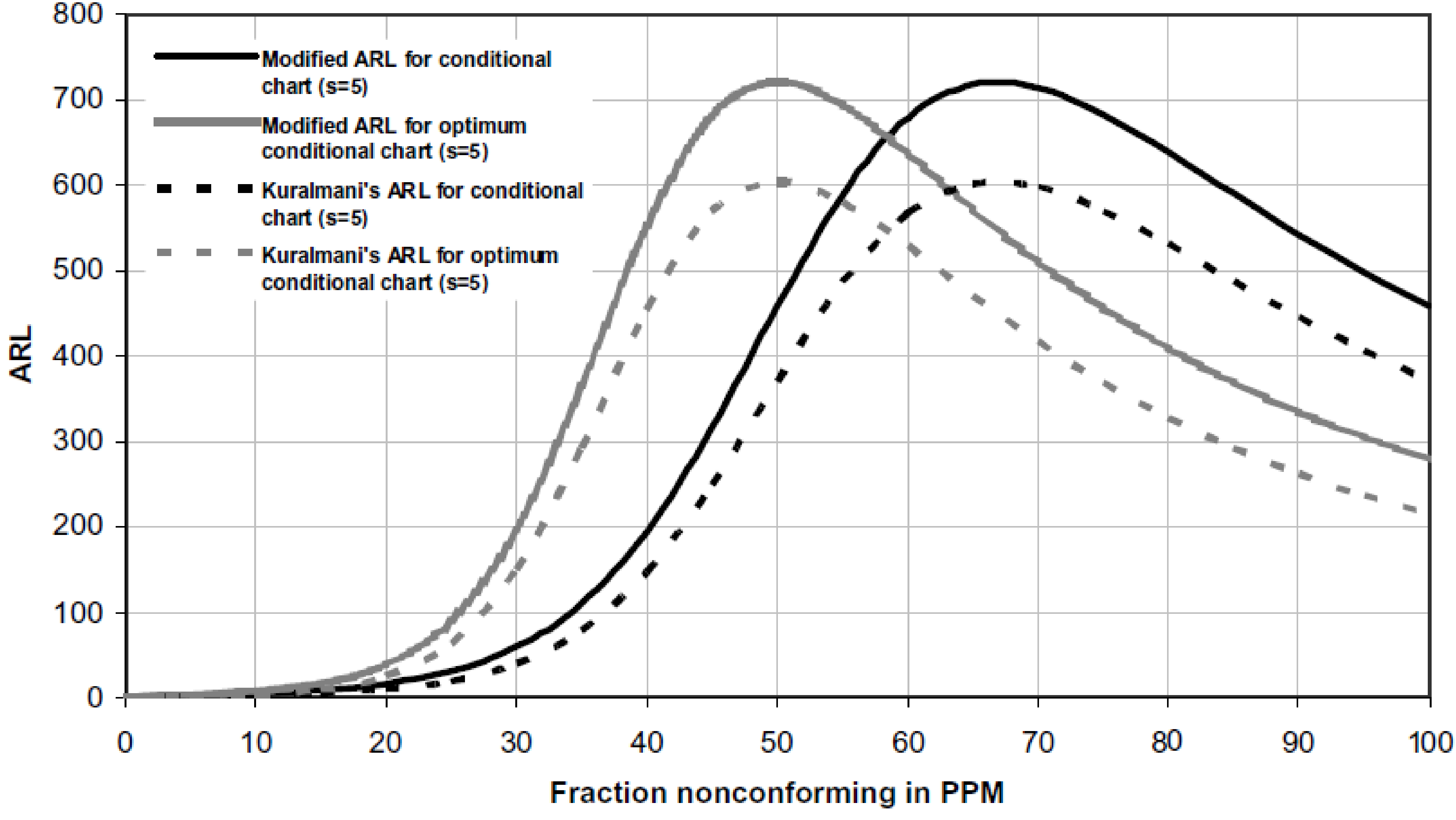

Fig. 2. ARL curves for $s = 5$ and $p = 50$ ppm.

4. Design of a conditional CCC chart

- 為了確定控制程序限制使用條件，我們進行如下：

1. Selecting the values for the desired s and in-control ARL (ARL_d),
2. Solving for δ in $ARL_d = (2-\delta^s)/[(1-\delta)(1-\delta^s)]$, and
3. 代入δ and p in Eqs. (1) and (2) to控制限計算程序的條件 or 代入δ and p in Eqs. (4) and (5) 計算最優控制程序限制了條件

Table 1

Values of δ in terms of various ARL and s values

Conditional number (s)	Average run length			
	100	200	370	500
1	0.89488	0.92675	0.94664	0.95427
2	0.92271	0.94676	0.96150	0.96710
3	0.93513	0.95568	0.96812	0.97281
4	0.94255	0.96101	0.97207	0.97621
5	0.94761	0.96464	0.97477	0.97854
6	0.95134	0.96733	0.97676	0.98026
7	0.95423	0.96941	0.97831	0.98160
8	0.95656	0.97109	0.97955	0.98267
9	0.95848	0.97248	0.98059	0.98357
10	0.96010	0.97366	0.98146	0.98432
15	0.96555	0.97763	0.98442	0.98688
20	0.96873	0.97997	0.98618	0.98839
25	0.97086	0.98156	0.98737	0.98943
50	0.97583	0.98540	0.99029	0.99197
75	0.97773	0.98700	0.99155	0.99308
100	0.97869	0.98790	0.99228	0.99372

Table 2
Values of LCL and UCL for optimum conditional chart for various process averages and in-control ARL = 100

s	Limits	Process average					
		0.000010	0.000020	0.000050	0.000100	0.000200	0.000500
1	LCL	7466	3733	1493	746	373	149
	UCL	407,396	203,697	81,478	40,738	20,368	8146
2	LCL	5411	2705	1082	541	270	108
	UCL	446,748	223,373	89,348	44,673	22,336	8933
3	LCL	4509	2254	901	450	225	90
	UCL	468,928	234,463	93,784	46,891	23,445	9377
4	LCL	3975	1987	795	397	198	79
	UCL	484,213	242,106	96,841	48,420	24,209	9682
5	LCL	3613	1806	722	361	180	72
	UCL	495,764	247,881	99,151	49,575	24,786	9913
6	LCL	3347	1673	669	334	167	66
	UCL	504,987	252,492	100,996	50,497	25,247	10,098
8	LCL	2976	1488	595	297	148	59
	UCL	519,105	259,551	103,819	51,909	25,953	10,380
10	LCL	2726	1363	545	272	136	54
	UCL	529,641	264,819	105,926	52,962	26,480	10591
15	LCL	2343	1171	468	234	117	46
	UCL	547,766	273,882	109,551	54,775	27,386	10,953
20	LCL	2120	1060	424	212	106	42
	UCL	559,665	279,832	111,931	55,964	27,981	11,191

Table 3
Values of LCL and UCL for optimum conditional chart for various process averages and in-control ARL = 200

s	Limits	Process average					
		0.000010	0.000020	0.000050	0.000100	0.000200	0.000500
1	LCL	5117	2558	1023	511	255	102
	UCL	453,563	226,781	90,711	45,355	22,676	9070
2	LCL	3673	1836	734	367	183	73
	UCL	493,748	246,873	98,748	49,373	24,686	9873
3	LCL	3038	1519	607	303	151	60
	UCL	516,614	258,306	103,321	51,660	25,829	10,330
4	LCL	2662	1331	532	266	133	53
	UCL	532,494	266,246	106,497	53,247	26,623	10,648
5	LCL	2407	1203	481	240	120	48
	UCL	544,555	272,276	108,909	54,454	27,226	10,889
6	LCL	2218	1109	443	221	110	44
	UCL	554,289	277,143	110,856	55,427	27,712	11,084
8	LCL	1956	978	391	195	97	39
	UCL	569,277	284,637	113,854	56,926	28,462	11,383
10	LCL	1777	888	355	177	88	35
	UCL	580,647	290,322	116,128	58,063	29,030	11,611
15	*LCL*	1503	751	300	150	75	30
	UCL	600,513	300,255	120,101	60,049	30,023	12,008
20	LCL	1342	671	268	134	67	26
	UCL	613,889	306,943	122,776	61,387	30,692	12,275

Table 4
Values of LCL and UCL for optimum conditional chart for various process averages and in-control ARL = 370

s	Limits	Process average					
		0.000010	0.000020	0.000050	0.000100	0.000200	0.000500
1	LCL	3682	1841	736	368	184	73
	UCL	493,469	246,734	98,692	49,345	24,672	9867
2	LCL	2627	1313	525	262	131	52
	UCL	534,071	267,035	106,813	53,405	26,702	10,679
3	LCL	2163	1081	432	216	108	43
	UCL	557,295	278,646	111,457	55,727	27,863	11,144
4	LCL	1888	944	377	188	94	37
	UCL	573,493	286,745	114,697	57,347	28,672	11,468
5	LCL	1700	850	340	170	85	34
	UCL	585,893	292,945	117,177	58,587	29,292	11,715
6	LCL	1563	781	312	156	78	31
	UCL	595,883	297,940	119,175	59,586	29,792	11,915
8	LCL	1371	685	274	137	68	27
	UCL	611,381	305,689	122,274	61,136	30,567	12,225
10	LCL	1239	619	247	123	61	24
	UCL	623,220	311,609	124,642	62,320	31,159	12,462
15	LCL	1037	518	207	103	51	20
	UCL	644,135	322,066	128,825	64,411	32,204	12,880
20	LCL	917	458	183	91	45	18
	UCL	658,485	329,241	131,695	65,846	32,922	13,167

Table 5
Values of LCL and UCL for optimum conditional chart for various process averages and in-control ARL = 500

s	Limits	Process average					
		0.000010	0.000020	0.000050	0.000100	0.000200	0.000500
1	LCL	3138	1569	627	313	156	62
	UCL	512,721	256,359	102,543	51,270	25,634	10,252
2	LCL	2234	1117	446	223	111	44
	UCL	553,420	276,709	110,682	55,340	27,669	11,066
3	LCL	1836	918	367	183	91	36
	UCL	576,772	288,385	115,353	57,675	28,836	11,533
4	LCL	1601	800	320	160	80	32
	UCL	593,042	296,520	118,606	59,302	29,650	11,858
5	LCL	1440	720	288	144	72	28
	UCL	605,546	302,772	121,107	60,552	30,275	12,108
6	LCL	1322	661	264	132	66	26
	UCL	615,651	307,824	123,128	61,563	30,780	12,311
8	LCL	1157	578	231	115	57	23
	UCL	631,348	315,673	126,267	63,132	31,565	12,624
10	LCL	1044	522	208	104	52	20
	UCL	643,367	321,682	128,671	64,334	32,166	12,865
15	LCL	870	435	174	87	43	17
	UCL	664,693	332,345	132,936	66,467	33,232	13,291
20	LCL	768	384	153	76	38	15
	UCL	679,259	339,628	135,849	67,923	33,960	13,582

- EX ：平均水準在0.00005，S=2 ，以及ARL=100時，其LCL與UCL值為1082以及89348

Table 2
Values of LCL and UCL for optimum conditional chart for various process averages and in-control ARL = 100

s	Limits	Process average					
		0.000010	0.000020	0.000050	0.000100	0.000200	0.000500
1	LCL	7466	3733	1493	746	373	149
	UCL	407,396	203,697	81,478	40,738	20,368	8146
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3	LCL	4509	2254	901	450	225	90
	UCL	468,928	234,463	93,784	46,891	23,445	9377
4	LCL	3975	1987	795	397	198	79
	UCL	484,213	242,106	96,841	48,420	24,209	9682

5. Conclusions

- 有條件的ARL值計算程序似乎是必要的，是為了計算出實際的ARL值
- 此篇可幫助業界進行參數查表。

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