

Rules for drawing CPA networks

- 1 The network must start and end on a single node.
- 2 No lines should cross each other.
- 3 When drawing an activity, do not add the end node straight away; wait until you have checked which activity follows.
- 4 There must be no lines that are not activities.
- 5 Due to the need to write figures in the nodes, it is helpful to draw networks with large circles and short lines.

- design the '3p off' packs
- estimate the sales volume for one month at 3p off
- get the special packs printed
- order extra raw materials (for example, a double order of cocoa)
- step up production
- arrange overtime for factory staff
- deliver promotional packs to shops ... and much, much more.

An efficient manager thinks about all the activities needed, and puts them in the correct time sequence. Then a network can be drawn up (see Figure 14.2).

Once the manager has found how long each activity is likely to take, she or he can work backwards to find out when the work must start. Here, the work must start 70 days before 1 February. This is because the longest path through to the end of the project is 70 (14 + 28 + 21 + 7).

Having drawn a network, the next stage is to identify more precisely the times when particular activities can or must begin and end. To do this, it is helpful to number the nodes that connect the activities. Figure 14.3 shows the 3p off example with the activities represented by letters and the nodes numbered.

14.3 Case example: the need for networks

A chocolate producer decides to run a '3p off' price promotion next February. Is there any need for network analysis? Surely not. What could be easier? Yet the risk of upsetting customers is massive with any promotion. What if a huge order from Tesco meant that Sainsbury's could not receive all the supplies it wanted?

To make this promotion work smoothly it would be necessary to:

- tell the sales force
- sell the stock into shops



Figure 14.2 '3p off' network (1)

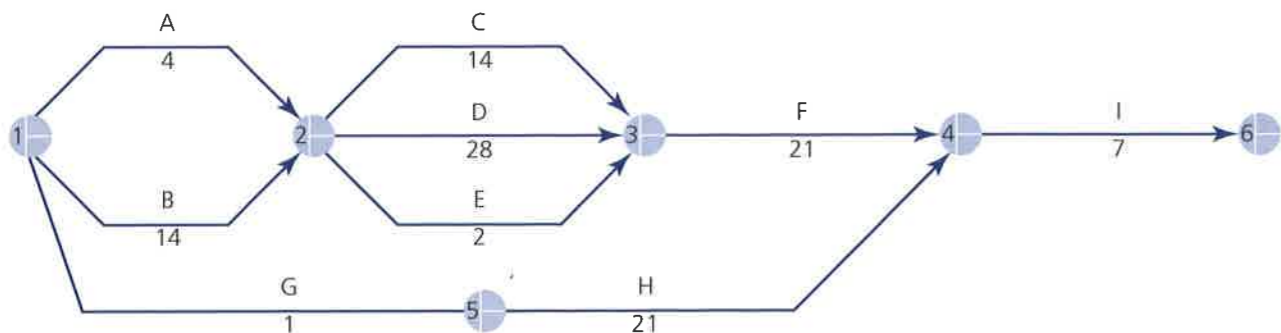


Figure 14.3 '3p off' network (2)

14.4 Earliest start times and latest finish times

Space has also been left in the nodes in Figure 14.3 for two more numbers: the earliest start time (EST) and the latest finish time (LFT). The EST shows the earliest time at which following activities can be started. On Figure 14.3, activities C, D and E can begin after 14 days, because that's when A and B are both finished.

Figure 14.3 shows the complete network, including all the ESTs. Note that the start of a project is always taken as 0 rather than 1. Therefore activities C, D and E can start on day 0 + 14 = 14. Activity F can start on 0 + 14 + 28 = 42. And the earliest the project can be completed is by day 0 + 14 + 28 + 21 + 7 = 70.

Calculating the ESTs provides two key pieces of information:

- 1 the earliest date that certain resources will be needed, such as skilled workers, raw materials or machinery; this avoids tying up working capital unnecessarily, for

instance by buying inventory today that will not be used until next month

- 2 the earliest completion date for the whole project (this is the EST on the final node).

The EST on the final node shows the earliest date at which the project can be completed. So when is the latest completion date that a manager would find acceptable? As time is money, and customers want deliveries as fast as possible, if next Wednesday is possible, the manager will set it as the latest acceptable date. This is known as the latest finish time (LFT).

The LFT shows the time by which an activity must be completed. These times are recorded in the bottom right-hand section of the nodes. The LFT shows the latest finish time of preceding activities. The number 42 in the bottom right-hand section of node 5 (Figure 14.5) shows that activity G must be finished by day 42 in order to give activities H and I time to be completed by day 70.

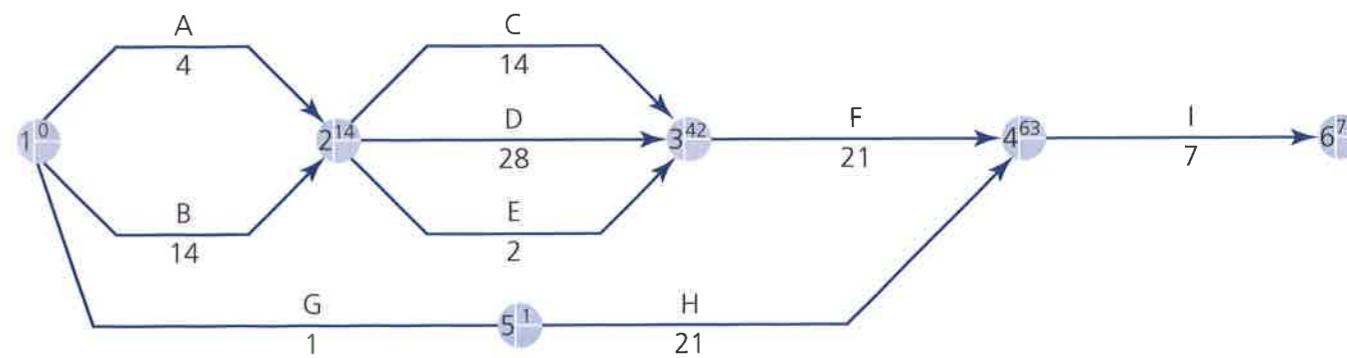


Figure 14.4 '3p off' network (3)

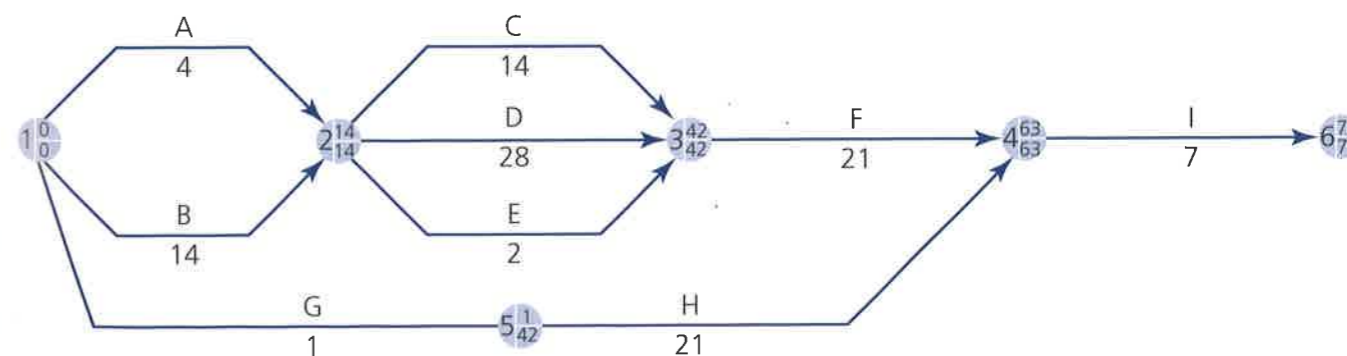


Figure 14.5 '3p off' network (4)

The LFTs on activities are calculated from right to left. In node 6 the LFT is 70, because that is the latest a manager would want the project to finish. Node 4 shows the LFT for activities F and H. Both must be finished by day 63, to leave seven days for activity I to be completed.

Calculating the LFTs provides three main pieces of information:

- 1 It provides the deadlines that *must* be met in order for the project to be completed on time.
- 2 It helps to identify the activities that have 'float time' – in other words, some slack between the EST and the LFT; activity H can be started on day 1 and must be finished by day 63, but takes only 21 days to complete; so there is no rush to complete it.
- 3 It identifies the critical path.

14.5 The critical path

The critical path comprises the activities that take longest to complete. They determine the length of the whole project. In this case, it is activities B, D, F and I. These are the activities that must not be delayed by even one day. For then the whole project will be late. With C, a delay would not matter. There are 28 days to complete a task that takes only 14. But D is on the critical path, so this 28-day activity must be completed in no more than 28 days.

Identifying the critical path allows managers to apply **management by exception**; in other words, focusing on exceptionally important tasks, rather than spreading their efforts thinly. Of the nine activities within the 3p off network, only the four critical ones need to absorb management time. The others need far less supervision.

If a supervisor sees a possibility that an activity on the critical path might overrun, she or he can consider shifting labour or machinery across from a non-critical task. In this way the project completion date can be kept intact.

To identify the critical path, the two key points are:

- 1 It will be on activities where the nodes show the EST and LFT to be the same.
- 2 It is the longest path through those nodes.

When drawing a network, the critical path is identified by striking two short lines across the critical activities (see Figure 14.6).

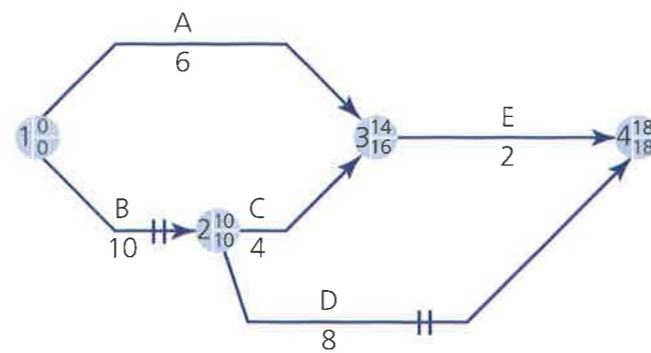


Figure 14.6 Indicating the critical path

14.6 Float time (non-critical activities)

Float is the spare time available for the completion of any activity. If an activity that takes three days must be completed within a week, there are four days of float time. These can be used to complete the task in a leisurely way, perhaps switching half the staff to another task. Alternatively, the task could be started on day four.

There are different ways of measuring float time, but this A level focuses solely on 'total float'. This measures the spare time available so that there is no delay to the overall project completion time. To work out the total float on any specific activity the following formula is required:

$$\text{LFT (this activity)} - \text{duration} - \text{EST (this activity)} = \text{Total float}$$

Applying this formula to Figure 14.5 gives the following calculations for total float times:

	LFT (this activity)	Minus duration	Minus LFT (this activity)	= Total float
Activity A	16	6	0	10
Activity B	10	10	0	0
Activity C	16	4	10	2
Activity D	18	8	10	0
Activity E	18	2	14	2

Table 14.1 Calculating total float

Note that the critical activities (B and D) have zero float time. This will always be the case. Once managers have calculated the total float on specific activities, they might get the job done straight away, then switch staff to other activities. Or the managers may allow staff the extra time to give more thought to the activity. For example, designing a new logo may need only two days, but it may well be that a better logo could be designed in five.

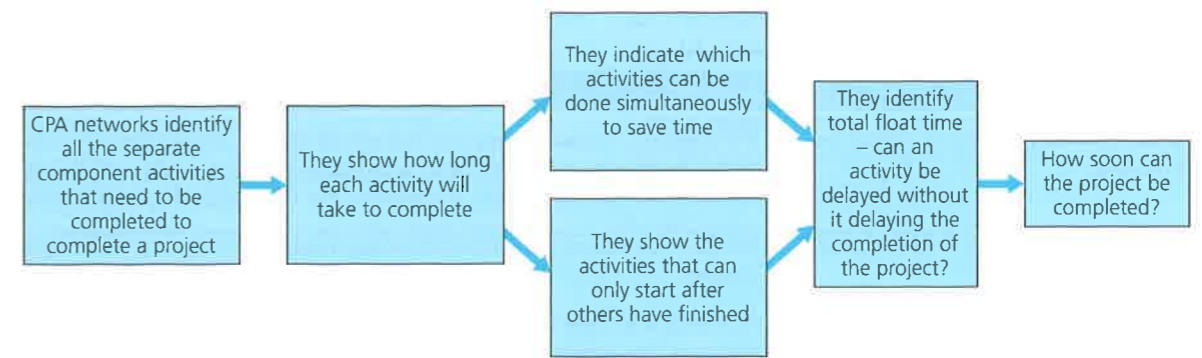


Figure 14.7 Logic chain: what do CPA network diagrams show?

14.7 Benefits and limitations of using network (critical path) analysis

Benefits

The benefits of using network (critical path) analysis are set out below.

- It requires careful planning of the order in which events need to occur, and the length of time each one should take. This should improve the smooth operation of an important project such as a new product launch.
- By identifying events that can be carried out simultaneously, it shortens the length of time taken to complete a project. This is an important element in the modern business focus upon time-based management. For example, if a law is passed that allows 14-year-olds to ride motorbikes with engines of less than 40cc, the first company to design and launch a suitable product would do extremely well.
- The resources needed for each activity can be ordered or hired no earlier than their scheduled EST. In this way cash outflows are postponed as long as possible, and the working capital tied up in the project is minimised.
- If the completion of an activity is delayed for some reason, the network diagram is a good starting point for working out the implications and deciding on appropriate courses of action.

Limitations

The limitations of critical path analysis are set out below.

- A complex project (such as the construction of the super-fast railway HS2) entails so many activities that a drawing becomes unmanageable. Fortunately, computers can zoom in and out of drawings, enabling small parts of the network to be magnified and examined.

- Drawing a diagram does not, in itself, ensure the effective management of a project. Network analysis provides a plan, but can only be as successful as the staff's commitment to it. This suggests that staff should be consulted about the schedule and the likely duration of the activities.
- The value of the network diagram is reduced slightly because the activity lines are not in proportion to the duration of the activities.

Real business

Delays can cost billions

In April 2015, American Airlines (AA) took delivery of its first Boeing 787 'Dreamliner'. It was three years late. AA placed the order for 42 787s in 2008, with a promised delivery date of 2012. That slipped back steadily into 2014, then 2015.

The problem arose because of difficulties with the new lightweight materials being used in the plane. The most serious was a redesign announced in 2009 to 'reinforce an area within the side-of-body section' of the plane! The direct cost to Boeing has been estimated at more than £4 billion. The indirect effects are no less severe. Before Boeing admitted that its project was behind schedule, its European rival Airbus was struggling to sell its competitor A350 plane. After Boeing's production delays became clear, Virgin Atlantic announced it was cancelling its Boeing order to buy Airbus planes. In 2010, Boeing received net orders for the Dreamliner of 36 planes, while Airbus enjoyed net orders for 78 A350s. Three years later the same issue continued to dog Boeing, with the Airbus 350 outselling the Dreamliner.

When the design problem became the critical one for Boeing, management failed to find a successful way of coping. In this case, poor critical path analysis cost Boeing £billions.

(Source: Airbus and Boeing websites: www.airbus.com and www.boeing.co.uk)

Five whys and a how

Questions	Answers
Why is it important to complete a project as soon as possible?	It's cheaper: if a project can be completed quickly, it will carry a smaller share of the organisation's fixed costs. In addition, customers do not like waiting. The quicker the completion, the greater the likelihood of repeat purchase.
Why is it important to identify activities that lie along a project's critical path?	Because delays on critical activities put back the final completion date for the project.
Why is it important to identify and calculate total float?	Activities that have float time are non-critical. They can be delayed without affecting the project's completion date. If a critical activity is delayed, resources can be transferred from other activities that have float time.
Why is it important to identify activities that can be completed simultaneously?	The goal should be to complete the project as soon as possible. If two activities can be carried out at the same time, they should be. It'll speed up the whole project.
Why is it important to calculate earliest start times and latest finish times?	This will help to ensure that specialist staff are only hired when needed. Don't hire bricklayers at the beginning of a project when they won't be needed for at least three weeks until the foundations are dug.
How do firms set about drawing network diagrams?	They identify all the component activities and estimate how long each will take to complete. Then they decide on the correct order for tackling the activities. Then they decide which activities can be carried out simultaneously. Now the critical path diagram can be drawn.

Key terms

Critical path: the activities that must be completed on time for the project to finish on time. In other words, they have no float time at all.

Float time: any spare time that arises between the completion of an activity and the starting time for the next.

Management by exception: the principle that because managers cannot supervise every activity within the

organisation, they should focus their energies on the most important issues.

Network: a diagram showing all the activities needed to complete a project, the order in which they must be completed and the critical path.

Network analysis: breaking a project down into its component parts, to identify the sequence of activities involved.

'The P in PM is as much about People Management as it is about Project Management.'

Cornelius Fichtner, management consultant

'Time is the only commodity that's irreplaceable: invest it, share it, spend it ... never waste it.'

Tracy Sherwood, author

'Nothing is less productive than to make more efficient what should not be done at all.'

Peter Drucker, management guru

14.8 Critical Path Analysis – evaluation

The cliché 'time is money' has been around for years. Only recently, though, have systems such as just-in-time focused clearly on time-based management. Time is vital not only because it affects costs, but also because it can provide a crucial marketing edge. Primark's key advantage over Marks & Spencer is that it is much quicker at getting catwalk fashions into high-street shops. So time can add value. Careful production planning can

also help to get a firm's new product to the market before the competition.

Critical Path Analysis is a valuable practical tool for taking time seriously. It involves careful planning and can be used as a way of monitoring progress. If critical

activities are falling behind schedule, action can be taken quickly. This serves as a reminder that successful business management is not just about clever strategic thinking. Ultimately, success depends upon what happens at the workplace or at the construction site.

14.9 Workbook

Revision questions

(30 marks; 30 minutes)

- 1 Identify two objectives of Critical Path Analysis. (2)
- 2 Distinguish between an activity and a project. (2)
- 3 State three key rules for drawing networks. (3)
- 4 Explain how to calculate the earliest start time for an activity. (4)
- 5 Why is it important to calculate the latest finish time on an activity? (4)
- 6 What is meant by 'the critical path' and how do you identify it? (4)
- 7 Explain why it would be useful to know which activities have float times available. (3)
- 8 Explain the value of Critical Path Analysis for a small firm in financial difficulties. (4)
- 9 Explain how the use of Critical Path Analysis could help a firm's management of time. (4)

Revision activities

Data response 1

Activity	Preceded by	Duration (weeks)
A		6
B		4
C		10
D	A & B	5
E	A & B	7
F	D	3

Table 14.2 Data for constructing a network

Questions (40 marks; 40 minutes)

- 1 a) Construct a network from the information given in Table 14.2. (6)
- b) Number the nodes and put in the earliest start times. (4)
- 2 a) Draw the following network: Activity A and B start the project. C and D follow A. E follows all other jobs. (6)
- b) Work out the earliest start times of the activities and put them in the nodes if, in

the above question, A lasts 2 days, B = 9 days, C = 3, D = 4, E = 7. (4)

- 3 a) Use the information given in Table 14.3 to construct a fully labelled network showing ESTs, LFTs and the critical path. (12)

Activity	Preceded by	Duration
A	–	3
B	–	9
C	–	2
D	A	5
E	C	3
F	B, D, E	5
G	C	9

Table 14.3 Data for constructing a fully labelled network

- b) If the firm were offered a £2,000 bonus for completing the project in twelve days, which activities should managers focus upon? Explain why. (8)

Data response 2

Every Friday needs managing

Last Friday had been a washout. Claire, Bren, Alliyah and Ruth had dithered over what to wear, where to go and how to get there, and ended up watching a rotten film in Bren's bedroom. This week was going to be different. Bren had just been taught critical path analysis and she was determined to use it to 'project manage' Friday night. As it was Bren's birthday on Friday, the others had to agree. They sat down on Tuesday to agree all the activities needed for a great night out. They started by focusing on the activities:

Alliyah: We have the best nights when we start at Harry's Bar for a couple of hours, then on to the Orchid at about midnight.

Claire: I like Harry's but prefer RSVP; no argument, though, we should go to the Orchid.

After half an hour back and forth, the agreement was Harry's at 9.00 and the Orchid at 12.00.

Then they realised that there was a lot more to it than that. It would take half an hour to get to Harry's and they'd have to get ready beforehand: bath, hair, nails, make-up. And what about the preceding activities? Shopping for a new top ... and shoes ... and earrings ... and getting some highlights done.

They argued about which comes first, a top and then shoes and earrings to match? Or the other way round? It was time for Bren to set it all out. See Table 14.4.

Activity	Preceded by	Duration
A Booking a hair and nails appointment	–	0.1 hours
B Clothes shopping	–	4 hours
C Shopping for shoes	–	3 hours
D Shopping for earrings	B, C	1 hour
E Hair and nails appointment	A	2 hours
F Bath	D, E	1 hour
G Make-up and get dressed	F	1 hour
H Constant phone conversations	–	24/7

Table 14.4 Activities required for a night out

Questions (20 marks; 25 minutes)

- 1 Draw up Bren's critical path diagram, to help plan her birthday. (8)
- 2 Calculate the float time available on activities D and E. (4)
- 3 Assess two factors that might cause Bren's critical path network to prove inaccurate. (8)

Data response 3

Slightly Mad delays Project Cars

The video games industry has grown enormously over the last decade. Slightly Mad Studios is a London-based company that produces video games for PS4, Xbox and Nintendo Wii.

Gamers are notoriously fickle. As a result, the typical video game tends to have a very short life cycle. This means that in order to survive, companies like Slightly Mad Studios must constantly innovate and come up with new games that excite the imagination.

In early 2013, designers at Slightly Mad began to develop a new driving game called Project Cars. The goal was to create the most authentic driving experience for gamers. Developing new games is usually a very expensive business. To help raise the finance needed to develop Project Cars, Slightly Mad Studios asked gamers to crowdfund the project. In return for their money, gamers would receive a share of the profits generated from Project Cars. The crowdfunding project succeeded, and over £6 million was raised. The plan was for the new game to be available for Christmas 2014.

In October 2014, the news broke that the release date for Project Cars had been delayed until March 2015. According to Project director Andy Garton: 'This delay has come about because a couple of other big games are launching around the same time as our planned first date. ... This would have had a very significant impact on our initial sales.'

The boss of Slightly Mad Studios, Ian Bell, also tried to explain the delay by stating that: 'Our goal has always been to deliver a landmark title that encompasses the wishes and desires of racing fans from all around the world; something with features and content powered by the community that provide a truly unforgettable and pioneering experience.'

Questions (30 marks; 35 minutes)

- 1 Assess how video game companies, such as Slightly Mad Games, might benefit from using critical path analysis. (10)
- 2 Evaluate Andy Garton's view that delaying the launch of Project Cars until March 2015 will help the company to maximise its revenues. (20)

Extended writing

- 1 'Using Critical Path Analysis to manage projects is as important to the finances and marketing of a business as it is to resources management.' Evaluate this statement. (20)
- 2 You have decided to start your own business: a fashion-focused clothes shop with its own website for online sales. Evaluate the extent to which Critical Path Analysis might help this new business succeed. (20)