

Design requirements for information sharing in a crisis management command and control centre

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ABSTRACT

Good support for information sharing and processing is essential for successful crisis management. A crisis manager handles information from many different sources and collaborates with many different actors. This study is therefore focusing on specifying some needs and requirements for information support systems for crisis management command and control centres. The study is based on case studies and interviews in Sweden with the aim to understand how information processing best can be supported from a crisis manager's perspective. The needs and requirements found in the study can be used in future system design or improvement.

Keywords

Information processing, crisis management support systems, information systems for command and control centres.

INTRODUCTION

Large disasters normally require many organizations and individuals (called actors) to be involved in the crisis management (CM) work. Efficient CM work depends on good collaboration and communication among them. Therefore, a good information support system is essential. There is much research that targets this topic, but there are no studies that describe the Swedish situation in detail, and this study tries to fill-in such a gap.

In Sweden, there are several different support systems in use. KriSam is one of them (Sundblom, 2008). Another system that is widely used and developed by the Swedish Civil Contingencies Agency (MSB) is Web-based Information System (WIS). WIS is a support system for information handling during crisis. It is used for getting in touch with other actors, and to share information that contribute to a common operational picture. Different systems have different advantages and disadvantages. More specifically, these systems are not designed with exactly the same purpose in mind, and there is no single system that is commonly used by all actors.

Two possible reasons contribute to this situation. Firstly, the relevant information is not integrated. The relevant information comes from different sources, such as from different sensors, expert systems, even from people's observations, oral conversation, e-mails and faxes. The integration process is often carried out in different actor's minds. A major consequence is that different actors may understand the operational picture differently and also that some important information may be ignored or forgotten. Secondly, the existing systems are developed by technical experts without putting enough consideration into usability issues. This makes these systems difficult to use, and holds them back from reaching the design purpose. Additionally it makes cross-organizational communication demanding. Designing efficient information supporting systems for CM is still a big challenge.

Large disasters are not common in Sweden, and it is not easy to predict their happening. A CM system should therefore also be a useful tool in daily work as pointed out by Van de Walle and Turoff: "One of the reoccurring problems in emergency preparedness is that tools not used on a regular basis during normal operations will probably not be used or not used properly in a real emergency." (Van de Walle and Turoff, 2008).

In order to help CM actors to build up a common situational picture, there are some projects that have been focusing specially on crisis information presentation, such as the OASIS project (Andrienko and Andrienko, 2007). The project aims at defining a generic CM system to support the response and rescue operations in the

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case of large scale disasters. The authors describe the following as the general requirements for intelligent visualization:

- Reduce the information load on the recipient: not only irrelevant information should be excluded but also the relevant information should be adequately aggregated and generalized leaving out unnecessary details.
- Choose representation techniques and design the display so as to ensure quick and accurate recognition of the meaning of the information conveyed.
- Take into account the characteristics of the medium used for viewing the presentation.

Systematized and timely information management is essential for CM, but often the designers of information support systems for CM forget one important design issue, and that is the usability of the interface towards its users. Normally, the users of such a system have a wide variety of backgrounds and experiences. Consequently, they will have different requirements and expectations of a support system. The ReliefWeb project (Naidoo, 2007) (Naidoo, 2007) indicated that usability improvements do make a difference. The ReliefWeb is a system for humanitarian aid information sharing. The system was redesigned between 2002 and 2005 with focus on usability.

Tufte (1997) gives nice examples of how important the visualization of information is for good decision making. In *Visual Explanations* Tufte gives the Challenger accident as an example of poor visualisation causing a disaster, and Snows map of cholera cases as an example of how good visualisation can help managing a crisis.

Crisis management organizations in Sweden

The formal CM organization in Sweden is complex. There are many different laws and decrees regulating everything from emergency response to disaster preparedness. In short there are three important principles describing how an extraordinary event should be handled:

- The person responsible for a service in normal circumstances is also responsible for it in an emergency (the principle of responsibility)
- In an emergency, public services function as far as possible in the same way as under normal circumstances.
- An emergency is handled where it occurs, by those immediately affected and those responsible.¹

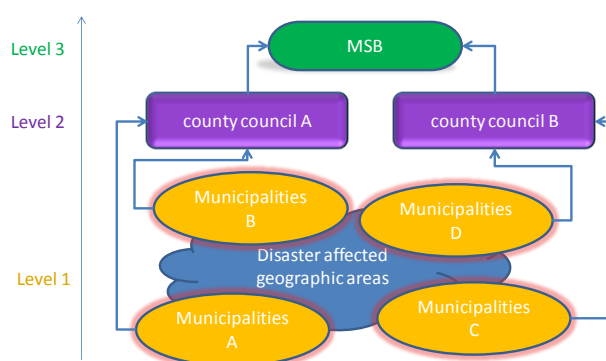


Figure 1. The structure of CM organizations

The *geographic responsibility for coordinating crisis management* is organized in three levels as showed in Figure 1. The first level is municipalities, or local councils which are geographically close to the disaster happening area. The second level is the county council level, which responsibility it is to support the municipal CM, especially when a crisis affects several municipalities. They can help coordinating information and are responsible for compiling a common operational picture on county level. On the third and national level the

¹ Translation of the principles into English collected from: <http://www.sweden.gov.se/sb/d/12126/a/89625>

geographic responsibility falls on the Swedish Civil Contingencies Agency (MSB). They are responsible for compiling a national common operational picture. WIS² and Raket³ are two systems developed by MSB.

As we mentioned earlier, there is no single systems that has been used by every actor in Sweden. Possibly due to that none of the systems can fulfil all requirements from the actors. The purpose of this study is to gain more insight into the following questions from a Swedish perspective: What are the actors' goals for CM? What information is needed to achieve the goals? How do they share information and collaborate with other actors? How do they create a common operational picture when many actors are participating in the CM? What problems exist today that may hinder efficient CM, both concerning information processing in general and the systems used?

METHODS

In this study, we have used case studies and interviews. The study is divided into two parts: The first part is a case study of two smaller disaster cases in the Gothenburg area. The purpose of the case study was to give us a broad picture of what happens to information communication during a crisis. The second part is a wide interview series with representatives from different actors. The interviews are not immediately connected to the previous case studies, but the knowledge gained from the case studies is the foundation for the interview series. The interviews also serve as a part of the evaluation of existing systems and as a future system design requirements study.

Case study

Two smaller events happened in Lilla Edet and in Mölndal, two municipalities nearby Gothenburg on the west coast of Sweden.

The first case is a sudden outbreak of a waterborne infection in Lilla Edet in September 2008. Approximately 350 persons were affected by stomach illness. The medical examination of people who were ill due to the drinking water showed presence of Caliciviridae, a virus that is the cause of winter vomiting disease.

The CM work was lead by a cross-organizational group consisting of representatives showed in Table 1:

the municipality of Lilla Edet	the National Food Administration	the county council	VAKA (the Swedish Water emergency Group)
the Swedish Institute for Infectious disease control	the Virological Laboratory at Sahlgrenska University Hospital	the health care centre in Lilla Edet	the Infectious Disease Control Unit

Table 1. CM group in the Lilla Edet case

We had the opportunity to follow the events as they were evolving, and conducted three interviews in collaboration with a neighbouring research group. The first interview was conducted at the beginning of the crisis with the head of the Environment department in Lilla Edet who was in charge of the local CM, to get an overview of how the CM was organized and how information was shared in this particular crisis. The second two interviews were follow-up interviews with the head of the environment department and with the chief executive in Lilla Edet. All interviews were voice recorded and approximately one hour long each.

By the time being, the media reports of the event as well as available reports and documents related to the CM events at the municipality in a chronological order were followed.

The second case was a flood in Mölndal in December 2006. For six months it had been raining more than usual, and in the middle of December the Mölndal River reached the highest levels in 146 years. This caused flooding

² http://www.krisberedskapsmyndigheten.se/templates/Page____10843.aspx

³ http://www.krisberedskapsmyndigheten.se/defaultEN____936.aspx

in wide areas from Kungsbacka (which is about 30 km south of Mölndal) to Partille (which is about 15 km north), however the most affected area was Mölndal and places near the Mölndal River. The train traffic, which is an important mean of transport for a large amount of daily commuters, was affected due to flooding in a tunnel, and buses had to replace the train traffic between Kungsbacka and Gothenburg. The car and tram traffic was also hindered because of water on the road between Gothenburg and Mölndal.

Two semi-structured interviews were performed with the security coordinator and the information coordinator of the municipality in the winter 2008. These two persons are responsible for coordinating the crisis preparedness in the municipality and have good insight in how municipal CM processes information. The two interviewees were interviewed together, and the interviews were followed up by further questions through e-mail. Both interviews were around one hour long and voice recorded.

Wide Interviews

9 interviews have been conducted with different CM actors. The interviewees were selected so that they have good knowledge about the CM in their specific organization.

The interviews are semi-structured. The questions cover the following areas:

- Organization
 - The background information about the interviewee him/herself and about how the CM organization looks like and what goals the actor has for CM.
- Information
 - What information the actor needs, and how information is collected, stored, and shared.
- Communication
 - How the actors communicate, collaborate with each other.
- Technical systems
 - What technical systems are used for CM support, information processing, and communication. If the actor has access to a command and control center, how is it organized?

The average duration of the interviews was more than one hour each with a few exceptions where the shortest interview was half an hour and the longest almost three hours. Table 2 provides background information for the actors that were interviewed so far.

	Actor	Interviewee
1	Municipality A	Security coordinator
2	Municipality B	Security coordinator
3	Rescue service in municipality B	Senior Fire Brigade Officer
4	Municipality C	Security coordinator
5	Municipality D	Security coordinator
6	Swedish National Road Agency	Security coordinator on national level.
7	County council A (not in the same area as the previous actors.)	Person responsible for the CM support system used in the county.
8	“Region” (A region is mainly responsible for health care but might also be responsible public transport and other areas that the municipalities in the region wish to collaborate about.)	Medical health care officer responsible for disaster health care preparedness.
9	County council B (not in the same area as the previous actors)	Security coordinator for it-issues and project manager for CM, risk analysis and information.

Table 2. Interviewee overview

All interviews were voice recorded, and in most cases complemented by written notes, sketches, photographs, or documents describing the actor's CM organization.

RESULTS

The case studies provided insights into how CM works during minor crisis events in a municipality in Sweden. In many small cases the full CM organization is not needed or started up within a municipality. Three important issues regarding information processing are:

1. Some important information can be difficult for the CM to find. This is in particular true at the early stages of a crisis. For example when people started to fall ill in Lilla Edet many were not sick enough to seek medical attention, but in the pharmacy, some specific medicine was suddenly sold in un-usual rate. As such information is not connected directly to the CM centre; it was not easy to find out that something was wrong and to locate the source of infection in earlier stage.
2. Some decisions are made in collaboration with experts. In Lilla Edet it was the municipality that had the geographic responsibility for the CM. It was however other actors that had the expertise and responsibility for infectious diseases control. Mainly the county medical officer, but also experts such as VAKA (a national water crisis expertise and support group), the Swedish National Food association, and the division for Infectious disease control. Other actors were of course also involved, but to a lesser extent. This means that if the actors would not have agreed about a course of action they might start up uncoordinated activities.
3. There are many different activities going on at the same time during a crisis and this means that information is needed from very different and unexpected sources. An example is that during the flood in 2006 the CM in Mölndal had to handle diverse issues such as:
 - a. give information to the public about alternative routes, since the main through route and many streets were flooded.
 - b. initiate testing of the drinking water when contamination was suspected.
 - c. moving municipal activities such as the public library when the buildings were flooded.
 - d. the traffic department provided sand bags to be used as protection from the water.

The issues that need to be handled are very different, and all require collaboration with different other actors.

The structure and function of command and control centers:

All interviewed actors have access to some kind of command and control centre during a crisis. However, there are large differences in how and how frequently these facilities are used.

Level 1

The command and control centers in level 1 (see Figure 1) are usually prepared in similar ways. They normally have access to phone (including special arrangements if the local switchboard breaks down), internet, fax, television and radio receivers, radio communication systems (that are used to get in touch with first responders such as the rescue service or police), whiteboards, projectors, and computer workplaces. It was also common to have paper copies of plans, checklists, or minutes from CM meetings.

There are many different approaches to how software is used. For documentation most actors use the same internal diary system that is used by that actor for daily reporting. There are special crisis information systems, but there is no regulation that forces all actors to use the same system, and the interviewed actors had different approaches to how these systems were used. For example, all but one of the interviewed actors had access to WIS. Of those who had access to WIS, one municipality used it exclusively for reporting to their county council, whereas others used it on a regular basis, for example to follow events in neighbouring municipalities or add information about their crisis preparedness. Those who often use WIS were satisfied with it, while those who were not using WIS as much assessed that they did not find the system useful for crisis preparedness.

The command and control centre in level 1 is usually not very large and might be a normal meeting room specially prepared for the purpose of CM. For a small crisis the CM group might be lead by a chief administrative officer who happens to be responsible for the specific area that the crisis is affecting. For a crisis that is affecting many different municipal activities the CM is lead by the chief executive of the municipality.

Other actors and experts can be included in the crisis management group either through a representative on site or through phone conferences. An overview of who might be included in the CM group is presented in Figure 2.

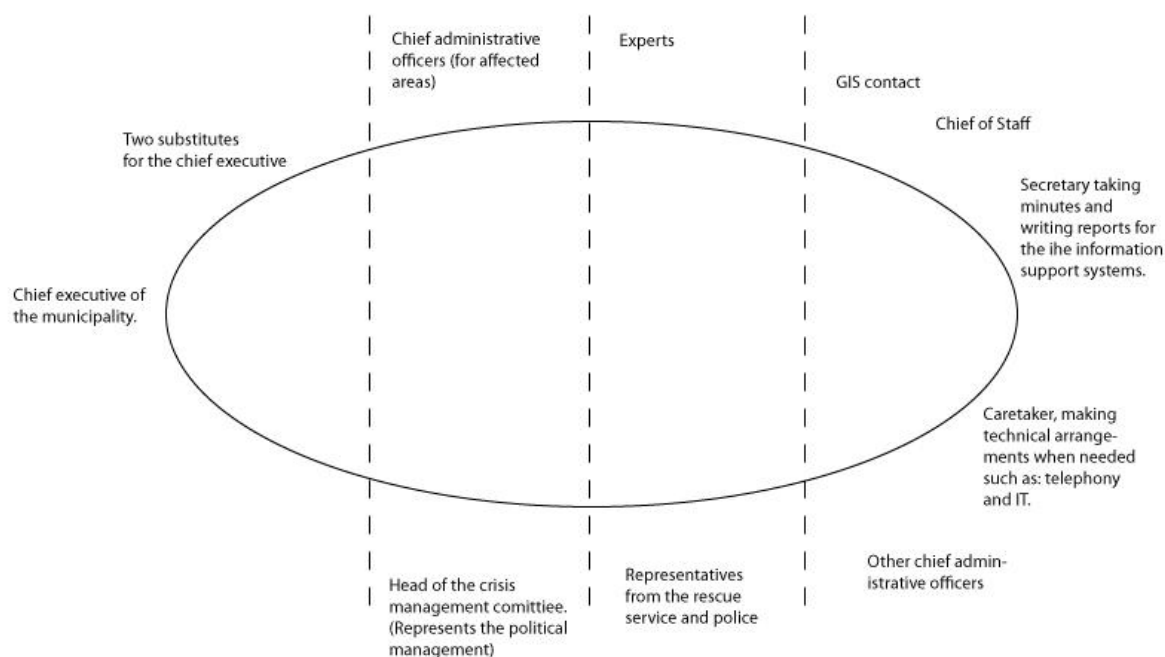


Figure 2. An overview of who is taking part in the municipal CM.

Figure 2 is based on the description given by one of the interviewed municipalities, and shows the participants around the meeting table in the command and control centre. In some municipal CM groups the command and control centre is only used for regular meetings, and then people return to their own desk. In other, the command and control centre is staffed all the time. Some municipalities rely on whiteboards, maps on the walls, and printed reports in files, while other have electronic “team boards” which allows the CM to share information with actors not present in the command and control centre.

The interviewed municipalities have different routines for exactly how the command and command centre is staffed. This also depends on how severe the crisis is. For a small crisis it might be enough to have regular meetings, after which the crisis managers return to their regular desks. If a crisis is severe, there might be a formal schedule that is followed to keep the command centre staffed. In this case there can also be formal routines for how tasks are passed on.

Most of the interviewed municipalities have an information centre located nearby the command and control centre in order to be able to easily forward information to the public through their web site, call-centre, and media contacts.

Level 2

The county council’s main tasks are to support the municipalities and help them get access to information, contacts, and resources they need in order to handle the crisis, and to compile a regional common operational picture. Therefore, they are more dependent on technology for information sharing.

At the two county councils that have been interviewed so far, the location and design of the command and command centre is more advanced, given that these centres need to be able to function after for example accidents in one of the nuclear power plants in the region. This means that the centre can be placed in an underground shelter and have extra power supply in case of power outages.

One of the interviewees described the crisis organization in their county as follows:

“The crisis preparedness organization consists of 40 individuals. When something happens, those who are available are informed. Who takes part in the CM depends on what competence is needed, and we do also have the option to ask experts within different fields to join the team.”

The same interviewee also comments the location that is chosen for the CM:

“We often prefer to sit in the same office space since this makes it easier for us to share information with each other.”

An example of a county command and control centre during an exercise is shown in Figure 3. Not visible in the picture are also whiteboards for sharing information within the group about for example current and planned activities, radio communication equipment, video conference equipment, and more.



Figure 3. A county council command and control centre during a crisis management exercise.

The interviewed county councils both use WIS, but have slightly different experiences. One of the interviewees said that WIS is a great tool for mass communication to involved actors. Information can be entered once, and everyone can get the same message and comment on it.

The other county council interviewee compared the information in WIS to information on internet. There is some good information, but it can be hard to find because there is a lot of information that is not interesting or relevant for the current situation in the system too. According to the interviewee, the system is not designed with real work situations in mind.

Another problem is that the regular portable computers are not allowed in the command and control centre, so the crisis managers might not have access to information stored on their personal computer.

Technical systems must fit into the daily work of an organization

It was considered positive if an event could be handled by the regular organization without having to use the formal CM plans. One county council emphasized that most of what could be considered as a CM work takes place behind the regular work desk using everyday equipment for communication and information handling. This was confirmed by the two case studies in Lilla Edet and Mölndal, where much of the CM happened in regular office environment. Even when there is a larger crisis during which the command and control centres are in use, the preventive activities and later mitigation is handled in the regular office environment. Note that this does not mean that CM control centres are not essential. They are definitely important for CM. The point is that since it is common that some CM takes place in regular office environment, support systems for CM should work in this context as well too to be really helpful.

The information types that need to be supported

Based on the discussions in the interviews the following types of information need to be handled in a crisis command centre, see Table 3.

Facts about the crisis	Information about resources	Documentation
<ul style="list-style-type: none"> •prognoses •what is happening right now, and what has happened •expert knowledge, which is needed to understand possible effects of the crisis and of possible actions •Information that the public is asking for 	<ul style="list-style-type: none"> •what activities are going on and who is responsible. •what is planned to be done, and when and by whom. •contact information 	<ul style="list-style-type: none"> •decisions •plans •meeting minutes

Table 3. Information to be handled in a CM system.

Design Needs for information processing systems

The need for the systems to be easy and fast to use was pointed out as an important issue. During CM there is no time to read long documentation and help files. Phone and e-mail are still the most powerful communication channels. Some interviewees expressed concern about system or power failure. This, together with the need for quick and efficient tools, was one reason for why some of the interviewed actors liked using low technology tools such as whiteboards or printouts of meeting minutes. Such result imply that the existing system (include WIS) are still not good enough to fulfil all the requirements.

All interviewed county councils and most municipalities are using WIS. However, not all of the interviewed actors were using it regularly. The general opinion was that there were many usability problems with WIS, but that the system is a usable tool for sharing information. For example, it is not possible to send SMS, or to send e-mail to a group, through WIS. This brings about problems when an actor needs to share CM information with other actors that do not have access to WIS, or who do not monitor it on full time basis.

It was clear from the interviews that all stakeholders should be using the same system. It would make their information sharing much easier if they did not have to use different methods to communicate with different actors. Obviously, a system that can fulfil the multiple requirements from different actors does not exist yet in Sweden.

A better integration and usage of different systems was requested as well. One interviewee discussed Geographic Information Systems (GIS), which have many good functions. They would have been of even better use if there was a better connection to different data sources. There was also a request for a video conference call system to be installed on the regular desktops.

Updated information in the systems was another important issue that was discussed during interview. The interviewees said their organizations often use the internet to access information from different stakeholders. For example to see weather forecasts at the Swedish Metrological Institute (SMHI). They believe the internet is a very usable for information sharing as long as it is not sensitive information, but are distressed about when an actor presents outdated information that is of no use or even can mislead decision.

Finally, several interviewees stressed that since the actors during a crisis have very different responsibilities and routines, any support system should be well adjusted to those different needs. It is awkward to use a system that does not fit together with other systems, goals, and routines in an organization.

Culture differences between actors

Another obstacle for good information processing is the different roles and responsibilities that the actors have. It is not the different roles themselves that cause a problem, but when the actors do not have a correct understanding of both their own roles and other actors' roles.

An example of this from the interviews is the hurricane Gudrun that hit southern Sweden in 2005. At that time there had been changes in the Swedish telephone system, which meant that the main phone company that previously had been state-owned now was a private company. Two interviewees mentioned that this caused

frustration, because the other actors had not really thought about that the phone company did not have the same responsibility to aid the public as had been doing as state-owned, and the actors were surprised when they did not get the response they expected. Two other interviewees, from the health sector and from a municipality, said they at present experienced similar issues in their area. Yet again, other actors were talking about that it can be difficult to understand information coming from experts, because experts often have a hard time explaining their very good knowledge in a way that is easy to understand for a CM actor with a different background.

DISCUSSION

Requirements

What lessons can be learnt for future system design and improvement? One important conclusion is that systems should fit into daily work. It is not possible to have a system that is only used during crisis since the users will forget when and how to use the system. One way to do this is by developing systems that are both usable in command and control centres and in regular office environment. This also makes the systems usable for CM tasks that are performed in regular office environment, for example planning crisis preparedness, analyzing risks, and networking with other actors.

Another requirement is that a system must be adjusted to the different working conditions different actors have. A large municipality in a rural area has different information needs compared to a small municipality in highly populated area, and a private actor has different needs compared to a governmental actor. The system should be able to focus on the specific information demands that are important for the specific actor, and also be able to adjust if the crisis event changes. Dantas and Seville get to a similar conclusion when they end their paper on implementing an information sharing framework by saying: “A major outcome of this research is that perceived barriers can be reduced if technology is employed according to an organisation’s needs rather than the other way around.” (Dantas and Seville, 2006)

The system needs to be able to “handle” all sorts of information sources, from a GIS-map to meeting minutes. Large amounts of information can quickly become confusing, and the challenge is to organize this in a meaningful way for the crisis manager. This means that any information should be presented clearly so that it is evident to the crisis manager what the information means and what can be done with it.

Finally, the system should be easy to use for the crisis manager. Searching for information or entering information should not be cumbersome.

Description of the target user

What can be learnt about the target user group? Crisis managers often rely on the network they have both inside and outside the organization. They often use phone, e-mail, internet, and meetings to communicate. A crisis manager on a high level often delegates tasks to a group or a person that has the most relevant knowledge (and according to earlier planning), for example to compile a needed map, be a press contact, or check what resources are available. In most cases the crisis manager will be familiar with the information system, but the system should be designed in a way that does not hinder an inexperienced substitute.

CONCLUSION

Crises today are often complex and difficult to overview. There are many different ways of communicating and many possible sources of information. This paper is one step on the way to better understanding of the needs regarding information support that exist in CM.

Future research

The next step of this project will be the creation of a concept model that can be tested and evaluated with representatives from the target user group. This testing will then be used as a basis for developing a prototype showing possible ways of integrating crisis information.

One existing topic that we intend to investigate further is the how the large amount of information sources can be handled. A crisis manager in a command and control centre has access to many different information sources, where some information is on web pages, in information support systems, on a whiteboard, in their e-mail inbox, in other actors’ expert systems, or in the discussion that arises during a phone meeting. How can all this be organized in way that does not overwhelm the crisis manager? How should it be organized in order to allow

the crisis manager to understand what is going on, and also to understand what affect different actions might have?

Mentioned earlier is that culture differences might be an obstacle for information sharing. It would be very interesting to see more research on how to design CM support systems, command and control centres, or other technology that can help the actors involved in CM to get a better understanding of their own role and the roles of the actors they collaborate with.

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