Design of Remote Control Systems using Super-Speed Ethernet and TCP/IP

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Abstract—In general, standard TCP/IP (transmission control protocol-internet protocol), which is called TCP/IP, is using as the communication basis protocol between any collections of networks that is connected. In this paper, using this TCP/IP implementation of remote control system and suitable program for long distance communication is proposed. This system can make system, which basic Ethernet and TCP/IP used system, to mini modeling, so all module that is using here can be used. Therefore, intention of this paper is to reduce expenses, to effective manage for plant and to increase of productivity as linking each plant of several factory to TCP/IP and Ethernet, and then many control plant and manager minimize the needed course.

Index Terms—Ethernet & TCP/IP, Mini Modeling, Remote Control, RF

I. INTRODUCTION

The system that is presented in this paper can be mini modeling the construction of system which using basic Ethernet and TCP/IP, and the module that is using in here can use at actual work. PC(Personal Computer) is cheap and most of them can do what PLC(Programmable Logic Controller) does, and any PC can be replaced with addition of permanent software. All programs programmed from window system, its convenient to use. This means any person who is mechanic engineer, electronic engineer or someone that has technical mind can solve problem of system. The things that happening in personal computer shows on screen, it can reduce processing problem solution and use testing function widely. In case of current factory automation, short distance control using control PC is majority most of all. With this consist of system, This paper decibels a implementation of remote like to research about system that access internet using Ethernet and TCP/IP, not even a short distance, so it can be more convenient, and show the possibility of controlling many devices from more longer distance, and make possible several devices of factories at many places to be central concentrated control. The purpose of this study is to reduce expenses, effective management of device at many places, and increase of productivity with united manufacturing process through connect each device with TCP/IP and Ethernet, so several control devices or manager cut down necessary stage. The communication net offers needed information conveniently and quickly. Based on these super-speed information communication net, there are showing various applied techniques like video conference, VOD (Video On Demand), remote medical service, remote education, remote security system, web camera, etc. For last 15 years, the technique has been developed that connect each network and could use it as one network. This technique was able to manage many kinds of hardware techniques as connecting different kind of network and having one standard communication point. Internet technique hides complicated part of network hardware and be able to communicate to computers with no matter with physical network which they belongs to. With this, it became possible to use computer services and their programs, which is being used from one network host, at different network host that far from it. Yet the control systems of these days consists of PLC that undertaking sequential control of high speed, DCS (Distributed Control System) that undertaking loop-control of low speed, and process control computer that charge of information management, it has problem about materialize all controller at one controller manufacturing company, and unite, extend system on users side. Current PC is doing even more work through same I/O(Input/ Output) interface that is being used at PLC.

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II. COMMUNICATION THEORY

2.1. Network theory

TCP offers reliable stream service between performing applies program in this kind, and communication channel of full duplex mode with no error. TCP manage loss packet concretely to recover and guarantee no defect of data. The applied program that use TCP set up connection to long distance applied program, send and receive data, and close connection when exchanging data is over. Typically, one applied program is active by server, long distance applied program wait for setting up the connection, and the other one is progressive client that actually initialize communication. TCP devices input stream with segment that small enough to fit at IP data program. After that IP transport each data gram to TCP the destination. To overcome the untrustworthy of data transportation service, TCP use acknowledgement with re-transmission mode. Each segment use serial number which distinguish that data that forwarded internal. When segment is received, TCP, the receiver, send

acknowledgement to sender for the mark about received segment. If the sender doesn't get the acknowledgement after waiting for a while, the sender assuming that data has been lost, and retransmit it.[1]

This is the form of TCP segment below.

0	8	16	24	31
Source Port		Destination Port		
Sequence Number				
Acknowledgment Number				
Offset	Reserved	Flags	Windows Size	
Checksum		Urgent pointer		
Options			Padding	
Data				

Fig. 1-1 TCP segment format

(1) TCP Segment Format

1) Source & Destination Port: Address both end of 16 bit virtual circuit.
2) Sequence & Acknowledge Number: Sequence Number shows the sequence from the sender's side, and acknowledge Number is applied by the sequence of received byte.
3) Data offset: Use to decide that start of data area.
4) Flags: Causes specific job at TCP.
5) Window Size: The destination of TCP use this item to control data flow.
6) Checksum: Data check-code by 16bit exclusive OR.
7) Urgent pointer: Shows the location of termination byte on emergency data's stream.
8) Option: Address option like maximum length of segment.

(2) Port Number

Port number is using for designating address at transport level. And port number has 16bit size, can have each different TCP of 65,535 connection at the same time theoretically. UDP(User Datagram Protocol) also use Port Number, gets each address space with TCP, so even same Port Number is not coincidence. And also, depends on host useful Port Number is controlled. Server's port number is fixed but client's port number doesn't matter only if Server doesn't designate special Port Number.

(3) TCP Flow Control

Flow Control at TCP is similar with flow control at instrumentation (HELC,X.25(LAPB,etc.)) number 2, 3 of OSI(Open System Interconnection). The difference is the data unit for low control is not PDU(Protocol Data Unit) but byte unit.

(4) Retransmission Strategy

If ACK(forwarding recognition) doesn't arrive within designated time, it retransmit. From senders send data, and error occurs, then data will be dumped. And sometimes data get lost in the middle. In these two kinds of situation, timer is over (sender), and after that it retransmission.

2.2. Ethernet

Ethernet is LAN which the Xerox announced in 1976. The method is CSMA/CD(Carrier Sense Multiple Access/Collision Detection) with the base band coaxial cable. The origin of idea is Aloha Net (1970) which is announced by university of Hawaii. Aloha net is formed of base station at Honolulu and dispersed terminal station at Hawaii. The forwarding between them can occur collision because of using space wave of UHF zone, and all station use same frequency. Base station detects collision and retransmit. This method is called CSMA (Carrier Sense Multiple Assess).[2]

(1) Round trip delay time

The signal that started at level one in communication network is same as time to returning back from the other end side in communication network, and it calls Round-Trip Delay Time. If the length of network assumes L(m), transmission speed of signal assumes C(m/s), then round-trip delay time R is 2L/C.

(2) Slot time

Round-trip delay time of Ethernet consider that signal speed of coaxial cable is 0.77 times of light speed, and also add delaying signal of transceiver or repeater, estimate maximum44.99μs. Actually it is given little more time than this in Ethernet, 51.2μs is defines as Slot time.

(3) Back-off algorithm

The number of retry upper bound is 15 times. That means when 15 times' retry has failed for collision, it assumes as sending error, and report to high order protocol. Collision keep occurs, communication is congesting, each node's latency is getting longer, congestions rate became to be eased. Back off algorithm does a kind of traffic control. In general, controlling traffic of communication network is called as flow control it's important function of protocol.

(4) Performance evaluation of CSMA/CD mode

CSMA/CD mode use random numbers to protect collision, if it has fixed load, traffic control of communication network should be computed as statistic method. Utilization ratio of communication network means that is showing how's communication network rate of congestion when a few sending station exist at communication network.

III. REMOTE CONTROL SYSTEM

3.1. Ethernet-PC based remote control system

Like the block Figure below, Ethernet-PC based remote control system connects to device control PC through from Main Control PC to Network, then control device control PC indirectly, and control the actual work device. This system's all the actual control is from device control PC, main computer request simple control to device computer with network function at control computer, that content is managed at device computer.[3]

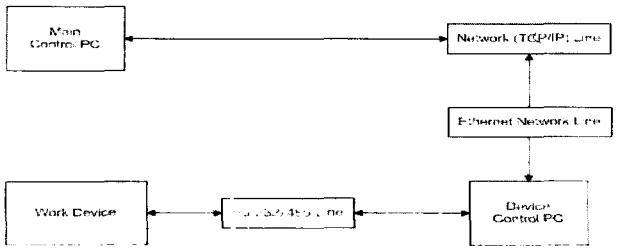


Fig. 3-1 Block diagram of Ethernet-PC based remote control system

(1) Main control PC : Use to control work device at remote site.
(2) Network (TCP/IP) line : Internet line to connect to device control PC at remote site.
(3) Device control PC : PC that is used for controlling work device actually.
(4) Ethernet line : Network to connect with control computer and work device from short distance.
(5) Work device : Mechanism manufacturing for work.

As you can this in this process, depends on the situation, it has to subsume a separate cable like RS232/485, and for each user protocol, it has to develop communication and manage program separately. And also, to correspond to user protocol, make additional Main Controller or to communication within product itself, additional part or program was needed. And for data communication between computers, mount appliance communication at main computer, was needed separate applied program at device computer. In case of modify system or configuration, if an error occurs to the situation device computer that is needed complex cable work and management, it cant actually controlling and monitoring all from Main computer and this system needs one control computer for one work device. In consisting system, it has defect that has to install computer for device separately.

3.2. Remote control system using Ethernet-RS232 mode

An advantage of this system is connect all connected work device with one Ethernet-RS232 conversion module, and controlling everything from one Main control PC through network and internet. Ethernet-RS232 conversion module convert network signal for needed device control to RS232 signal. In figure 3-2, managing control object at Main Control PC, so remote controlling is possible whenever and wherever is an advantage.

It shows that on work device with no existing additional control PC can control several devices through network.

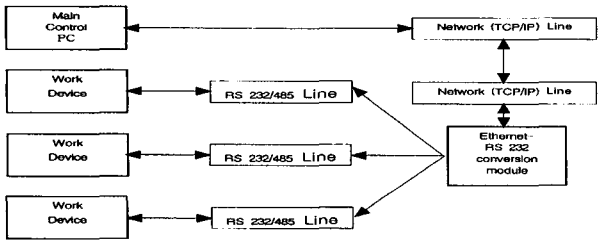


Fig. 3-2 Remote control system block diagram using Ethernet-RS323 mode

If user equipment mount embedded equipment that can be compatible with internet, user can access to LAN cable anywhere, control/monitoring, and can extend and linkage user equipment.

Also, it shows advantage that can be controlled RS232 equipment all and easily with one PC in LAN environment. Moreover, because Ethernet-RS232 conversion module grant self-IP number and get implementation, several user who access to homepage can build internet control system that can have condition/action of work device.

3.3. Implementation of remote control system

(1) Ethernet-RS232 conversion module

Ethernet, and it makes the data is getting converted to RS232. This equipment is to control it through network based on Ethernet and TCP/IP that connect with electronic equipment which retain RS232 serial communication interface, or to send/receive data between user and equipment.

So, its role of protocol conversion which received RS232 serial data from equipment convert to Ethernet, and then send it through network as TCP/IP data format and, Ethernet TCP/IP data that are sending convert to RS323 serial data and sending to equipment.

At Ethernet controller, it performs framing of addressing all data, detecting error or collision and avoidance.[4]

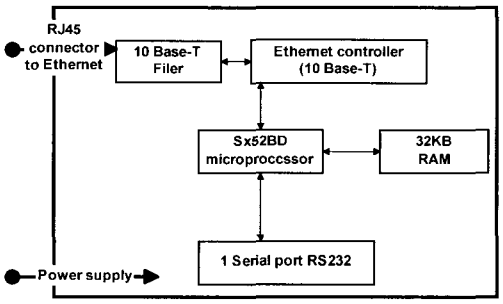


Fig. 3-3 Block diagram of Ethernet-RS232 conversion module

(2) RF sender/receiver module

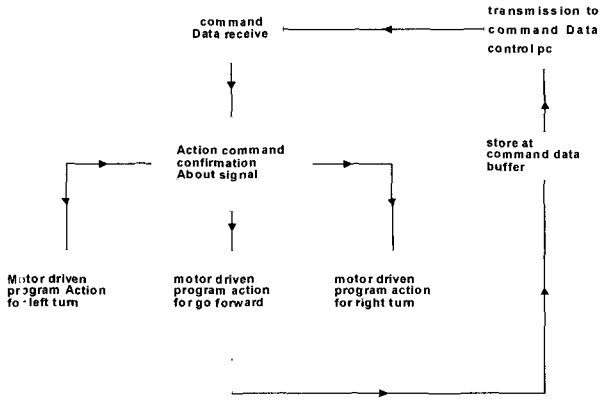
RF sender/receiver module has low power UHF(Ultra High Frequency)FM sender, receiver together, and has data recovery function, RX/TX auto-conversion circuit, and suitable for both-side short haul data link.

This module, for high transmission speed data (maximum 40Kbps) and fast TX/RX conversion speed (<1ms), is suitable to use for 1:1 link, or multi-node packet switch network, and also speedy RX/TX's power up time (<1ms) make possible duty cycle power saving for efficient power source management of battery used receiver side.[5]

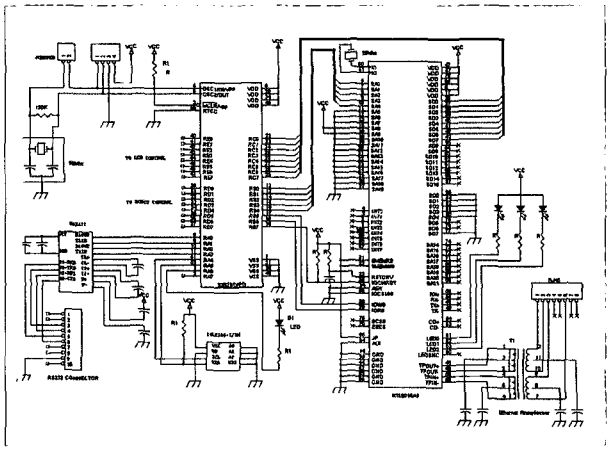
(3) Portable robot system hardware

This is controlling systems that receive wireless input command data, and send driven signal to step-motor. SX52BD which is one of the SX family is used for main processor unit as shown in figure 3-4.

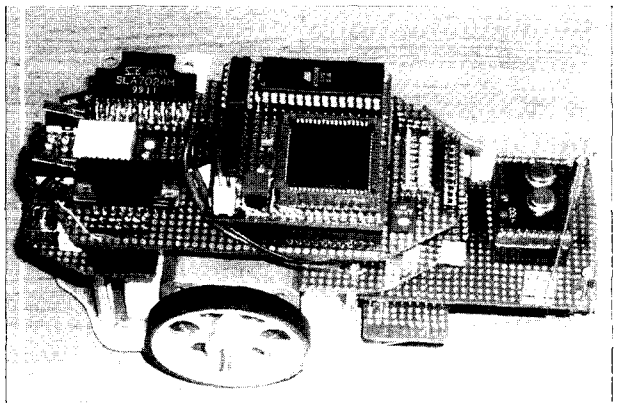
SX52BD is RISC architecture type processor and its operating speed is very high.



(a) flow chart



(b) main circuit diagram



(c) system

Fig. 3-4 Portable robot system hardware

(4) Portable robot system software

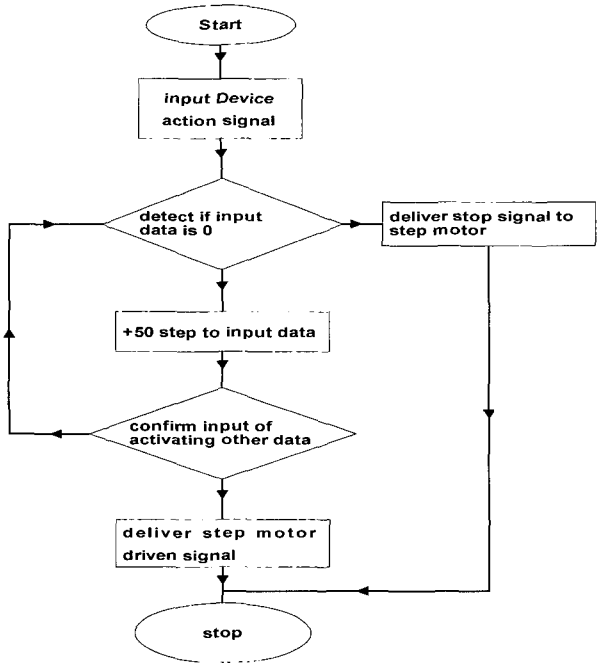
To fix the problem, in this thesis, confirming keys ir put and program of maintain the action is inserted to portable robot system.

Portable robot systems reaction speed depends on transmission speed of RF module, in this thesis, fast ir put speed of keypad was supplemented with repeating lc op because of transmission speed of RF module is *9.600bps*.

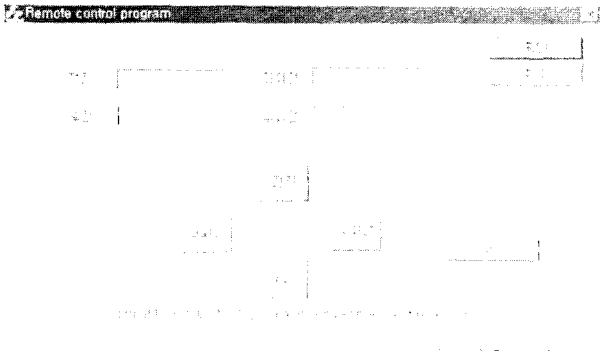
In the paper experiment, to reduce delay time, transit simple portable command data system has formed, and program has built in to portable robot system that has gotten the signal, and made it to move with simple movement command.

To remote control of portable robot system, telnet program is used. The program is written using C language and is very useful program for internet connection.

Figure 3-5(a) is the flow chart for system software and (b) is the command window for remote control.



(a) flow chart



(b) remote control window

Fig. 3-5 Portable robot system software & remote control

IV. EXPERIMENT RESULTS AND CONSIDERATIONS

This study used TCP protocol, Ethernet as listed above, and used RS232 transmission system, RF module as basic transmission system, and implemented remote control system experiment. Experiment above, data transmission has experimented through internet line actually. Data error rate of each transmission speed and the most safe transmission speed has measured. Measure type has experimented by sender/receiver of data block and Robot

system move times. This whole system's block diagram is below.

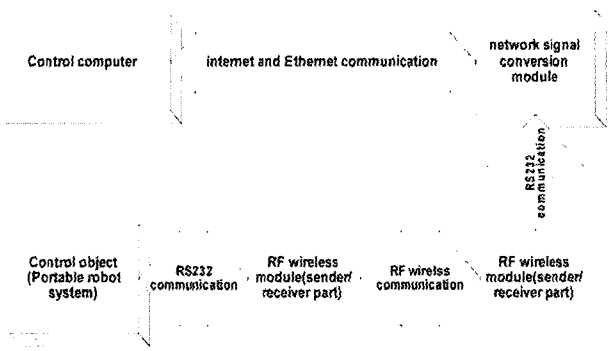


Fig. 4-1 Data transit block diagram of remote control system

The block diagram as shown above, from control computer to internet, it send command data of control object through internet and TCP network, and sent data at Ethernet network signal conversion module converted to RS232 through RISC microprocessor, and with using this, exchanging data is completed through RF wireless communication.

This system's advantage is simple command system and small command capacity, it is formed of model that reduces internet delay time.

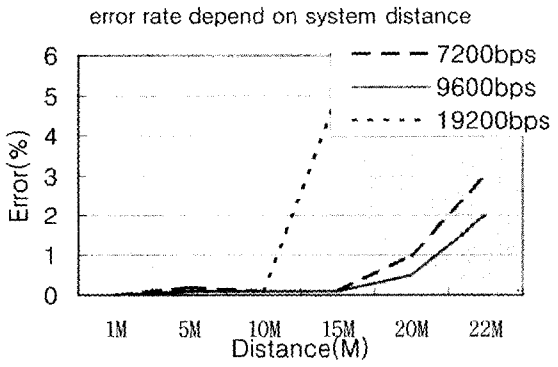


Fig. 4-2. Error rate per transmission speed

Table 4-1 Error rate depend on distance and transmission speed

Transmission Speed Distance	7,200bps (%)	9,600bps (%)	19,200bps (%)
1M	0.0	0.0	0.0
5M	0.2	0.1	0.1
10M	0.1	0.1	0.1
15M	0.1	0.1	10.0
20M	1.0	0.5	80.0
22M	3.0	2.0	-

Figure 4-2 and Table 4-1 above show data error depend on transmission speed. This experiment measured letter package error that is sending from portable robot through RF module after throughout the internet line and Ethernet.

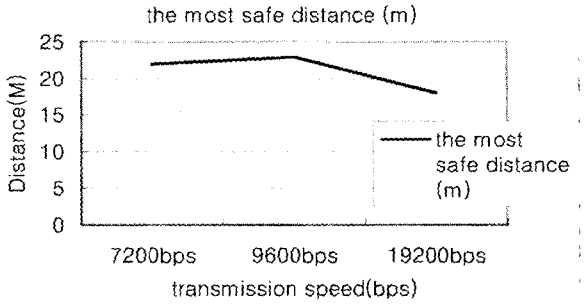


Fig. 4-3 The safest distance of transmission distance per transmission speed

According to Figure 4-2, Table 4-1 and Figure 4-3 above, when the transmission speed is 9,600bps, it recorded the lowest error. And more, transmission distance at 9,600bps was the most safe data sender to the longest distance.

On this experiment, noise on internet and error of odd behavior by noise is excluded. In the case of RF module, current using model for general experiment reacted to power supply and noise within building, showed letter data error.

At 7,200bps, both transmission speed, and moving distance is included to allowed error span, and at 9,600bps also was included to allowed error span. However, at 19,200bps, error span has got wider when it's over 10M, it showed problem to use actually. Moreover, transmission distance has showed as the closest.

Transmission of other bps was all data error, couldn't do experiment. The above experiment, it has confirmed 9,600bps is most safe data sender/receiver speed.

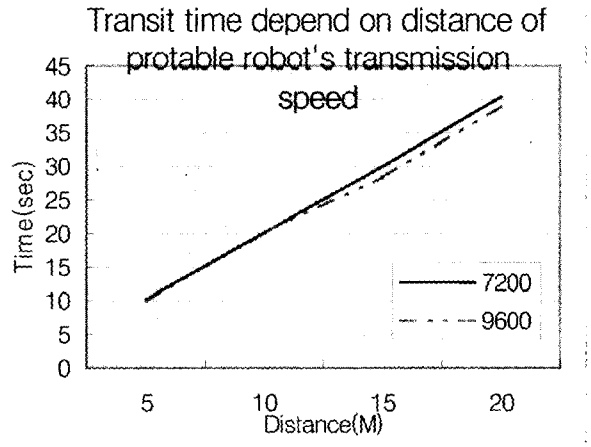


Fig. 4-4 Transit time depends on distance of portable robot's transmission speed

Table 4-2 Transmission time and average speed at 7,200bps

Distance (m)	Transit Time (sec)	Average Speed (m/sec)
5	10.17	0.49164
10	20.20	0.49505
15	30.00	0.50000
20	40.40	0.49505

Table 4-3 Transmission time and average speed at 9,600bps

Distance (m)	Transit time (sec)	Average Speed (m/sec)
5	09.85	0.507614
10	20.17	0.495786
15	28.36	0.528914
20	39.00	0.512821

Figure4-4 measured transit distance taken time of portable robot by transit speed, and measured the delay time of data transit speed by bps. The average speed of 7200bps has showed stable speed as 0.49543m/sec at Table 4-2 and the average speed of 9,600bps could get 0.51128m/sec at Table 4-3.

Both two experiment above has performed in all same condition, with result above, in case of 9,600bps, fast transit time, because driven system of portable robot used stepping motor, in case of 9,600bps, fast input pulse, has little more fast speed.

V. CONCLUSION

In here, Design of Control Systems using Super-Speed Ethernet and TCP/IP is presented. And action experiment through internet network has done.

The most important problem in this paper was stable data's transit speed of RF module that was used as wireless module. But sent data's error rate for wireless control of within ±2% was actually 7,200bps and 9,600bps. Due to drop of RF module's stable transit speed, it has problem of being restricted to data sender.

Results from this, it can't process all the data of device, it causes a problem that data delay time is increases when forwarding large amount of data. Device's control data that came in through network has to forward in wanted time but due to data delay, it causes odd behavior at control of device. Still, RF module transit speed, to transit stable data, since conserving 9,600bps it most trustful and most fastest transit speed in this thesis, the differences of transit speed between RF module and Ethernet controller can be secured by Ethernet memory some with buffer function, but if RF module to device's transit method does not add correction on basic system design, the more data transit is difficult.

However, the amount of data which current device demands is increasing. Device has to send large amount of data for complex, various control, user has to receive data about many kinds of condition of device from device to maintain more stable system. If it can increase stable transit speed of RF module, this system can build system that is more stable and more valuable to use.

In this paper, it has built the system that sending simple command of portable robot, but if, more advanced, building system that portable robot's sensor and camera is used, and connect interface of this system to web server, many people can observe, manage, and repair many kinds of devices at anywhere, in the various field, not even like device remote control, system, which is used on this paper, can be applied and formed.

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