



2010 US-China Electric Vehicle and Battery Technology Workshop

The Control Network of Fuel Cell City Bus

Report by

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Contents:

- ◆ Project Background of FC Bus
- ◆ Control System Design of FC Bus
- ◆ The Control Network Design
- ◆ The Wireless Communication Protocol
- ◆ Demonstrations and Conclusions



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- Up to 2010, the demonstration of Fuelcell Vehicle in the world.





Project Background of FC Bus

Project of FC City Bus: China 863 Hi-Tech. Plan

- ◆ Fuel Cell: $H_2 + O_2 = H_2O$, Output Electricity, Zero Emission, Quiet.
- ◆ In 2001, the 10th National 5 Year Research Project: FC City Bus.
- ◆ In 2004, the 1st Generation FC bus was evaluated.





Project Background of FC Bus

Project of FC City Bus: China 863 Hi-Tech. Plan

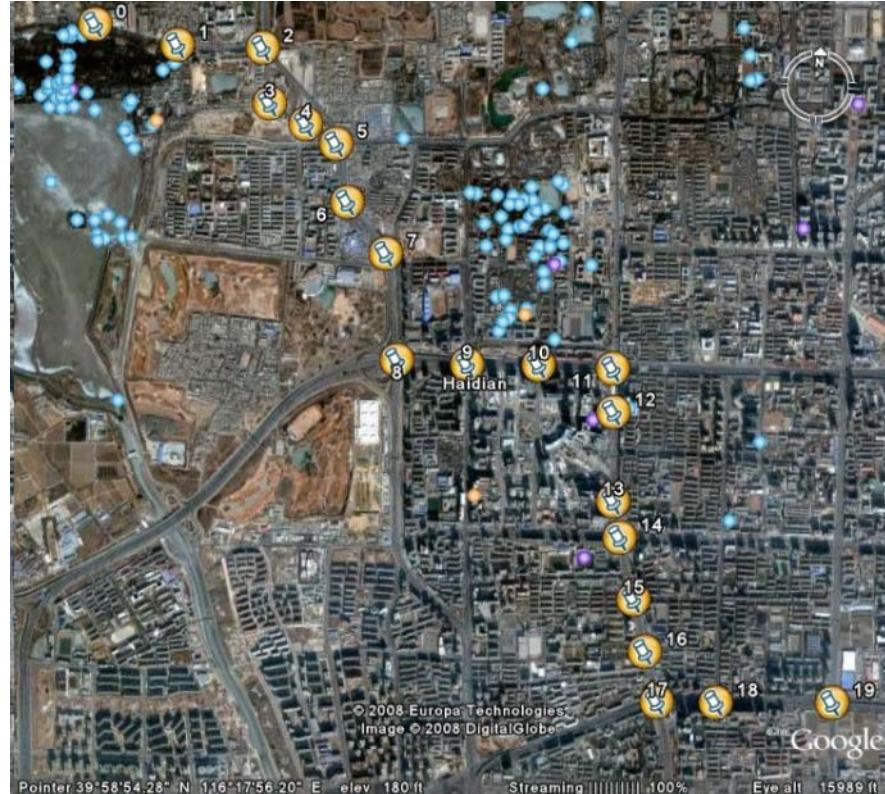
- ◆ In 2006, this Project is continuously support by 11th National 5 Year Plan: To construct 3 new FC buses, planed to demonstrate in 2008 Beijing Olympic Games.
- ◆ In April, 2008, FC Bus fleet started running on road for test.
- ◆ In July, 2008, FC Bus fleet started running in Bus Line No. 802, From station of North Gate of Summer Palace (颐和园北宫门) to station of East Gate of Republic University of China(人民大学东门) for demonstration, continuously until for one year.



Project Background of FC Bus

Project of FC City Bus: National 863 Hi-Tech. Plan

Peiking Univ. Tsinghua Univ.





Project Background of FC Bus





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Control System Design of FC Bus

Control System Design of FC Bus–Vehicle Parameters

Vehicle Length	12m
Vehicle Weight	13,000kg
Wheel Radius	0.51m
Maximum Vehicle Speed	80km/h
Power Bus Operating Voltage	320V~420V
Li battery	80Ah, 384V
Fuel cell Engine, Peak Power	100kW
Fuel cell Engine, Specific Power	50kW
DC/DC Specify Power	120kW
Traction Motor, Specify Power	60kW
Traction Motor, Peak Power	120kW
Maximum Torque of Motor	900Nm

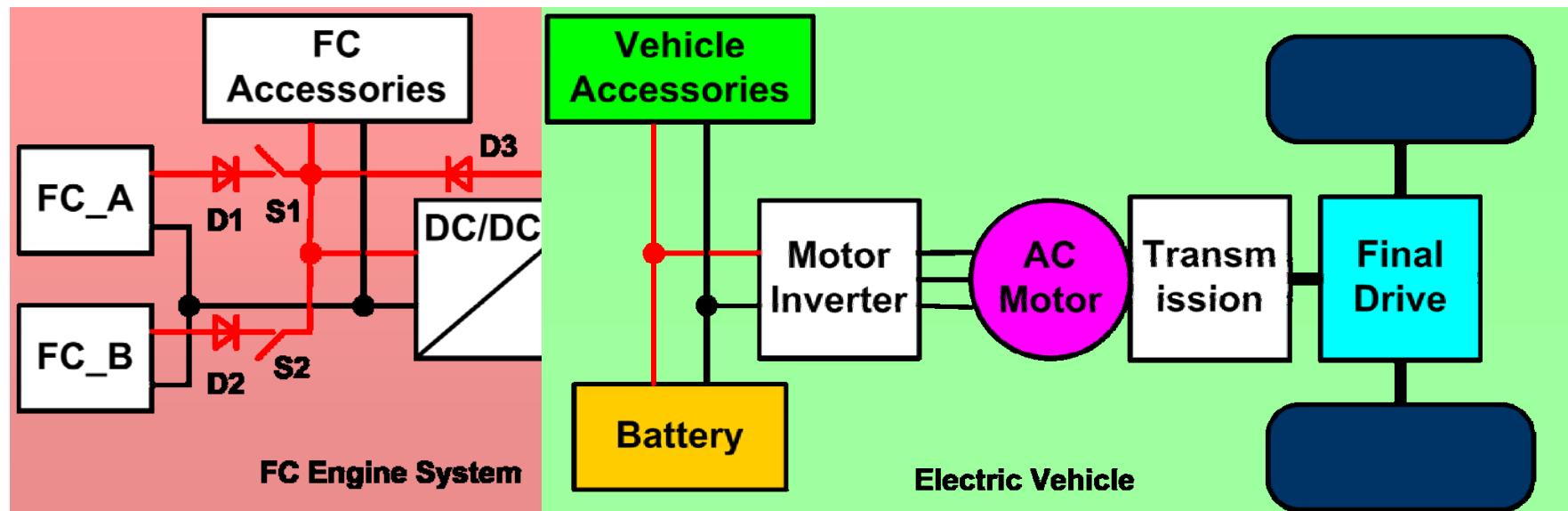




Control System Design of FC Bus

Control System Design of FC Bus--Powertrain

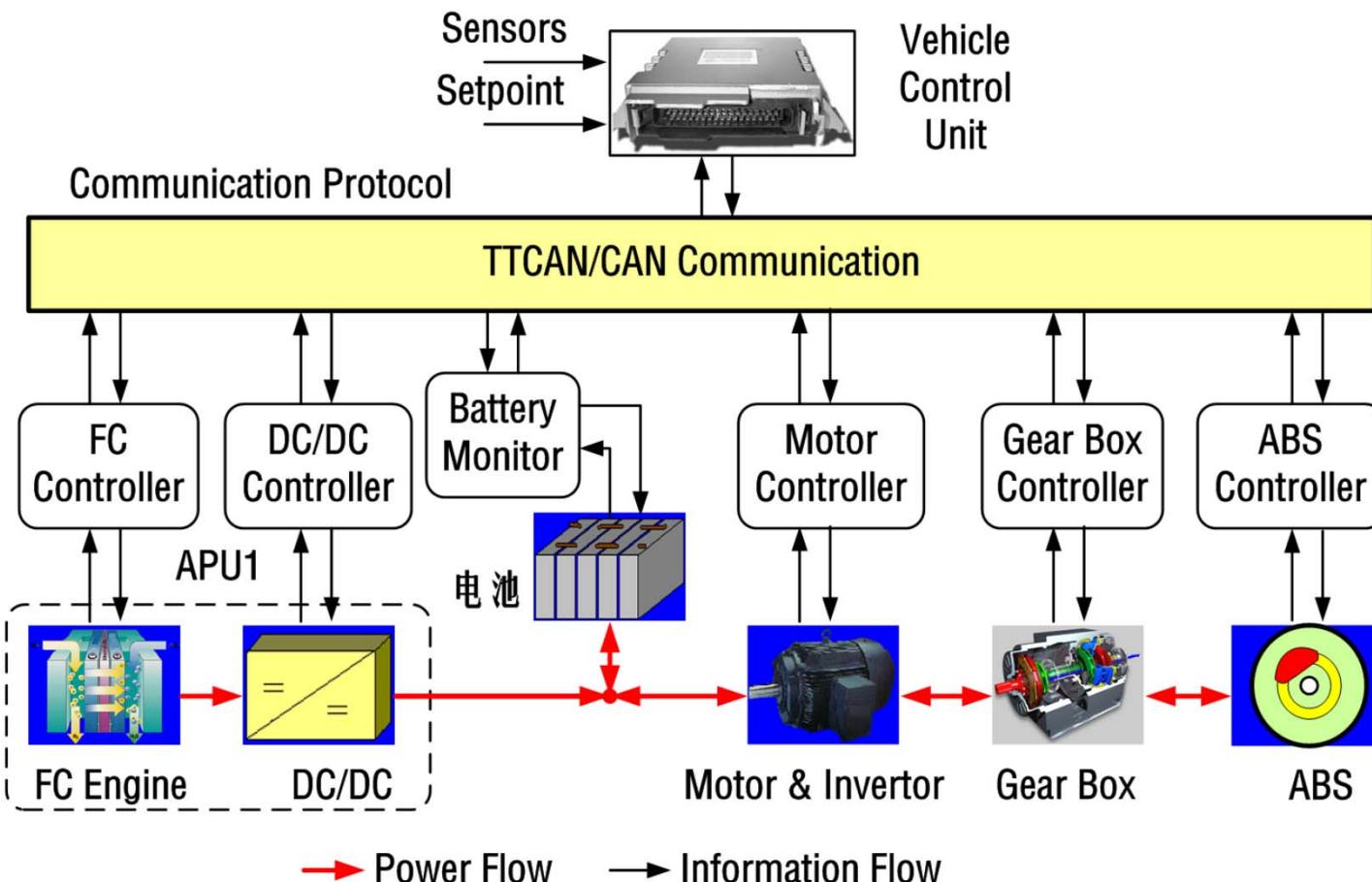
- ◆ Series Hybrid Configuration
- ◆ Battery + Motor = Electric Vehicle, 30km, 80% SOC
- ◆ FC Engine: soft run, like power station





Control System Design of FC Bus

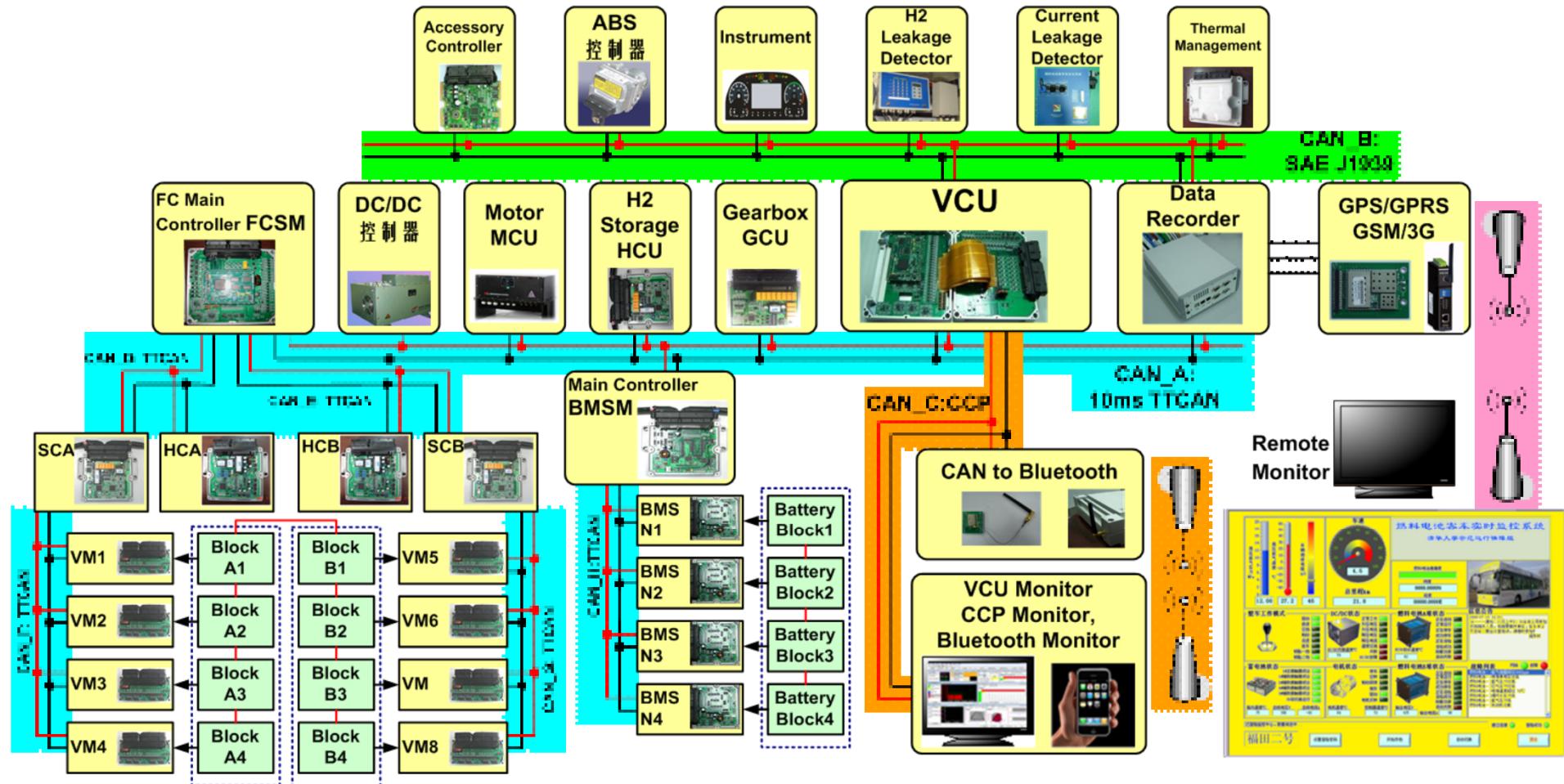
Control System Design of FC Bus--System Structure





Control System Design of FC Bus

Control System Design of FC Bus—Control Network





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Contents:

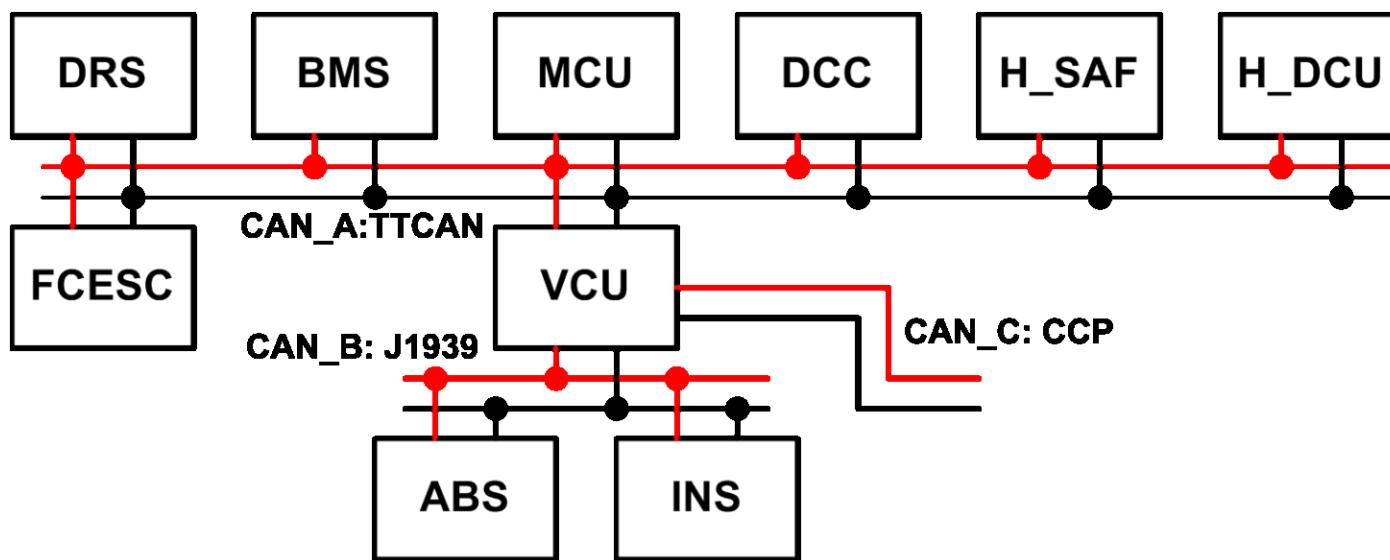
- ◆ Project Background of FC Bus
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The Inner Vehicle Network Design

● Inner vehicle network:

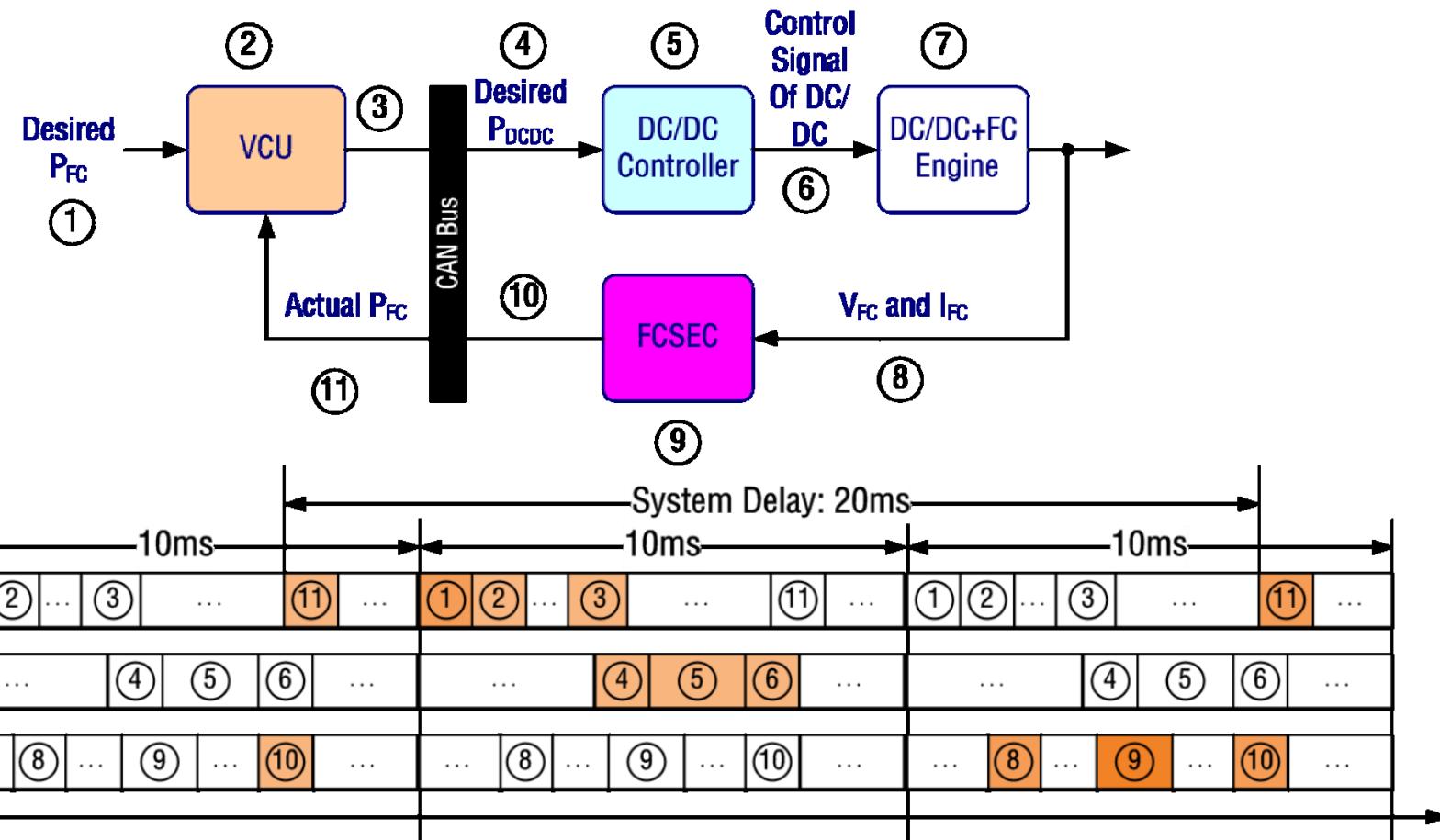
- ◆ TTCAN: Time Triggered CAN, Real time critical control, 10ms basic period, 250kbps
- ◆ CAN: Compatible J1939 (250 kbps) for traditional control systems, including ABS and Instrument.





The Inner Vehicle Network Design

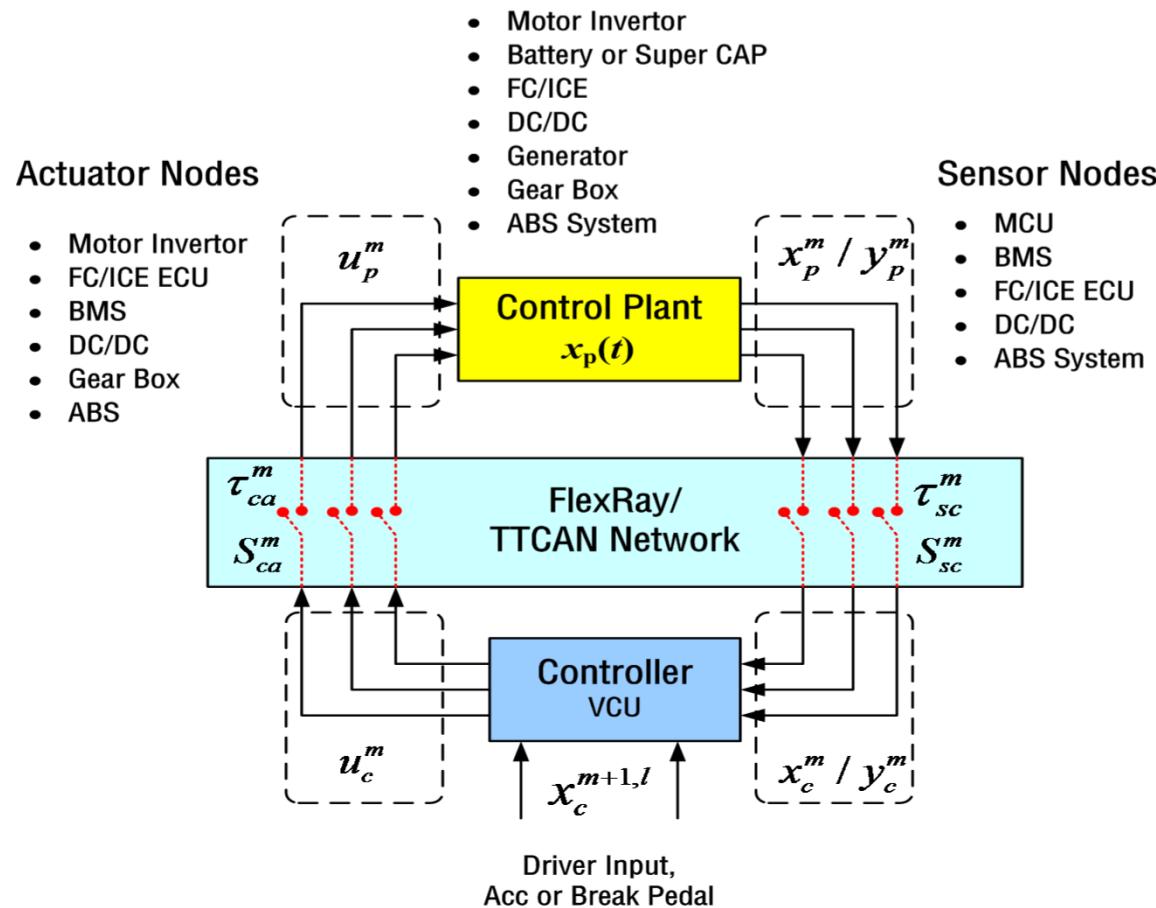
- Optimize the schedule of control tasks and the schedule of communication tasks—Network in the control loop





The Inner Vehicle Network Design

- Analysis the control system behavior under certain or random failure



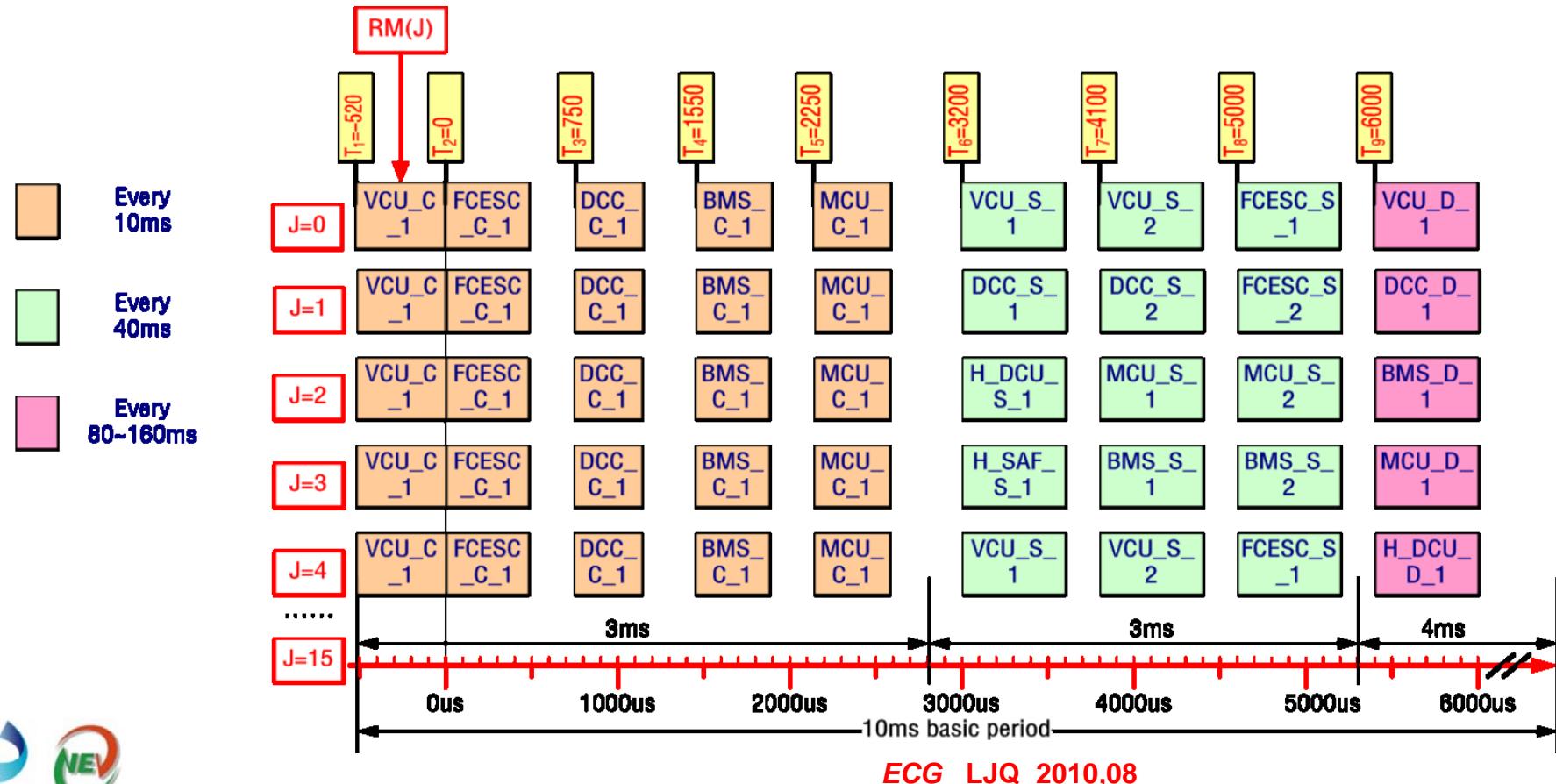


The Inner Vehicle Network Design

● Inner vehicle network:

◆ TTCAN Matrix for multi-rate message communication

Control message: 10ms, slow state message: 40ms, diagnostic message: 80~160ms



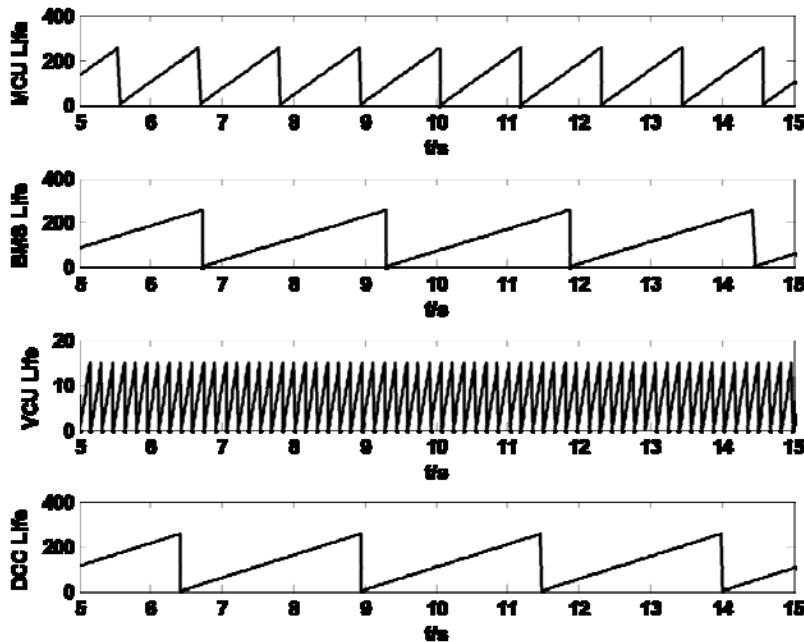


The Inner Vehicle Network Design

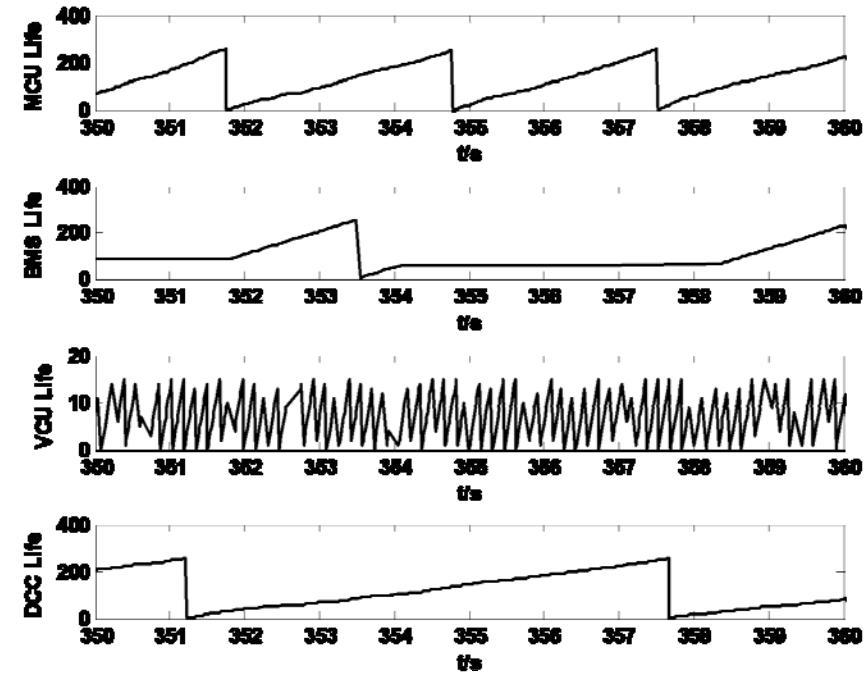
MCU and Process Monitor Algorithm

- ◆ VCU Internal Monitor: Processor & Process Monitor
- ◆ VCU Outside Monitor: TTCAN Error Monitor

TTCAN was normal:



TTCAN was Abnormal

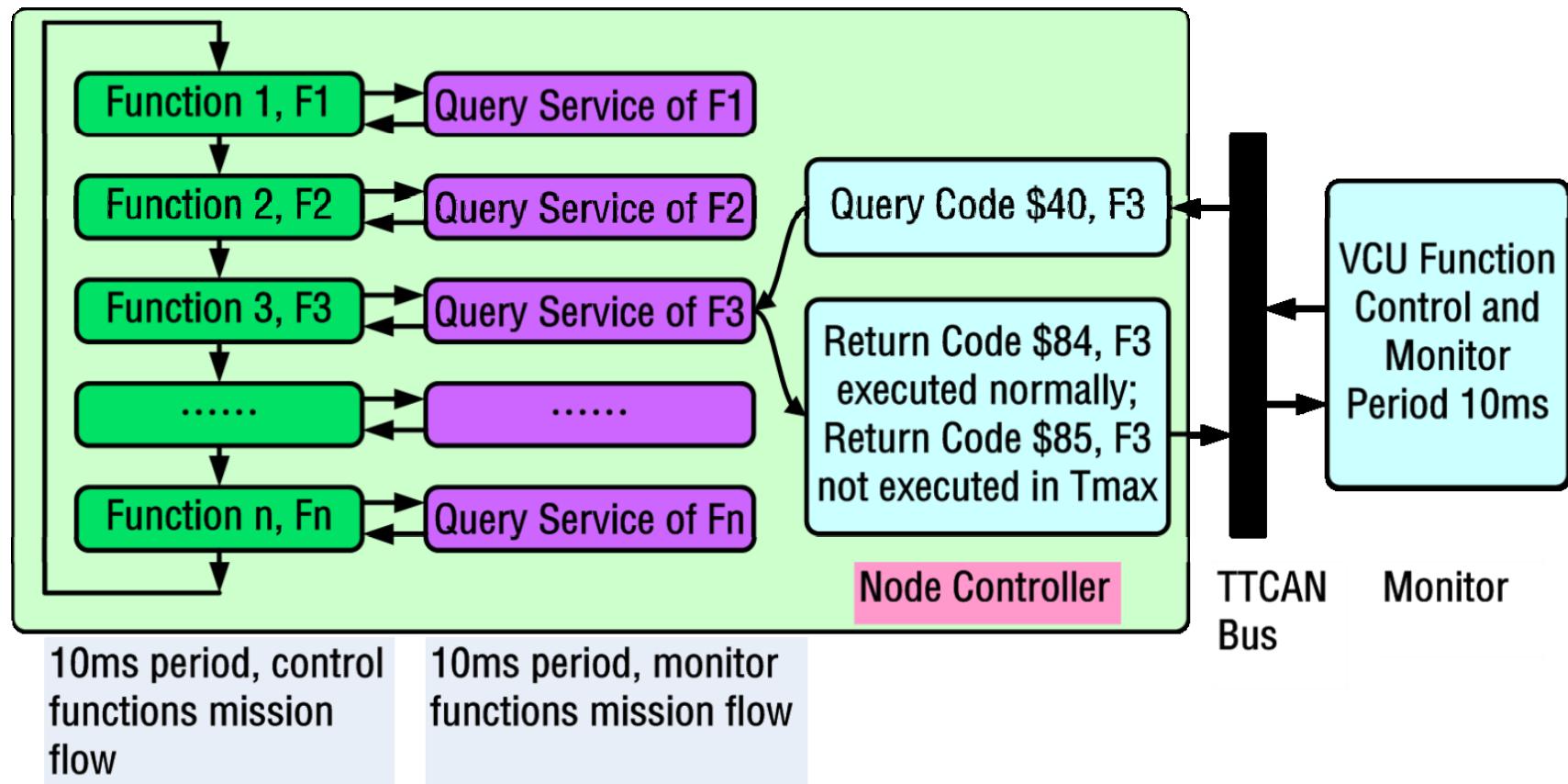




The Inner Vehicle Network Design

MCU and Process Monitor Algorithm

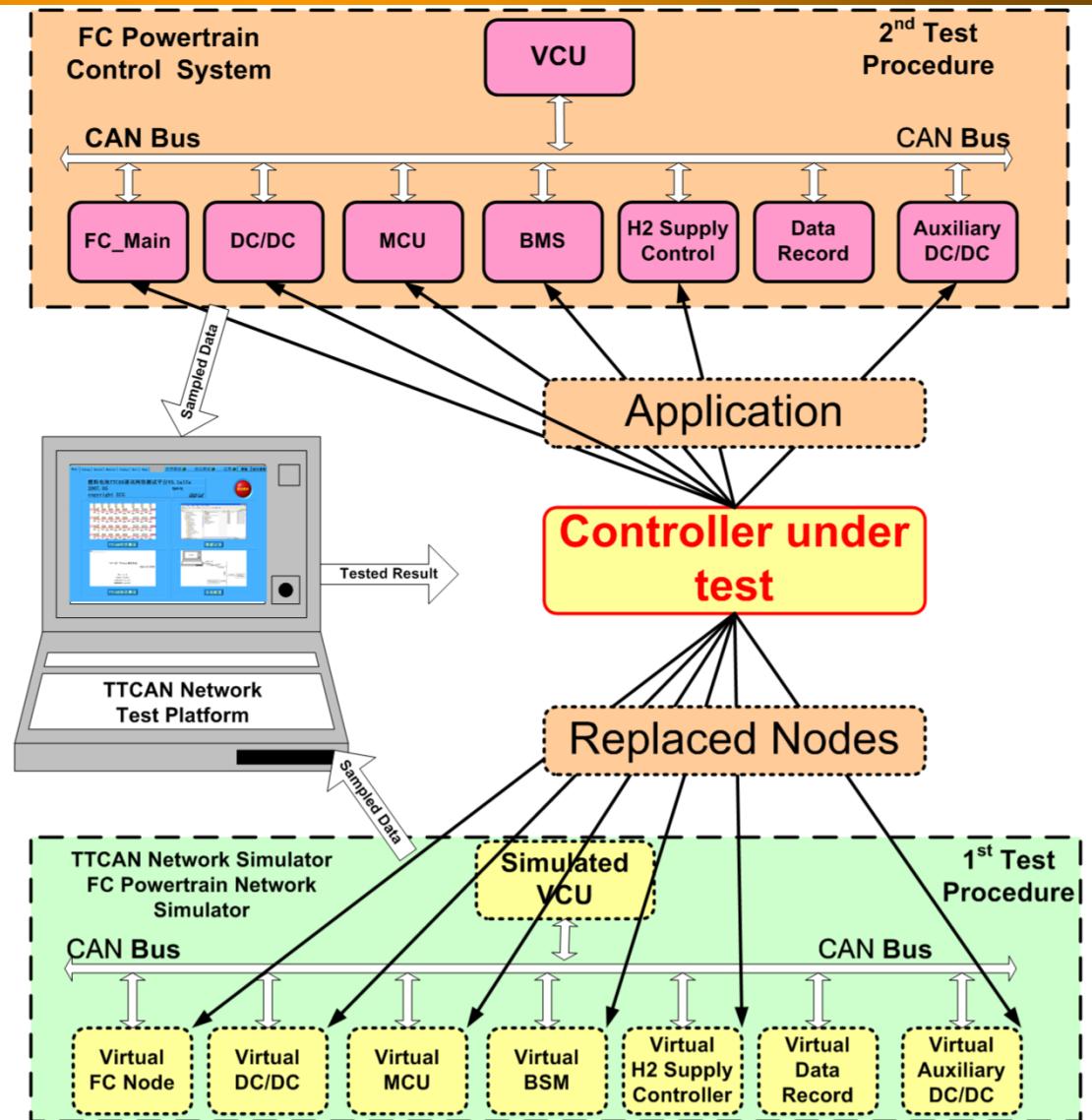
- ◆ VCU Outside Monitor: Sub-Nodes Monitor via TTCAN





The Inner Vehicle Network Design

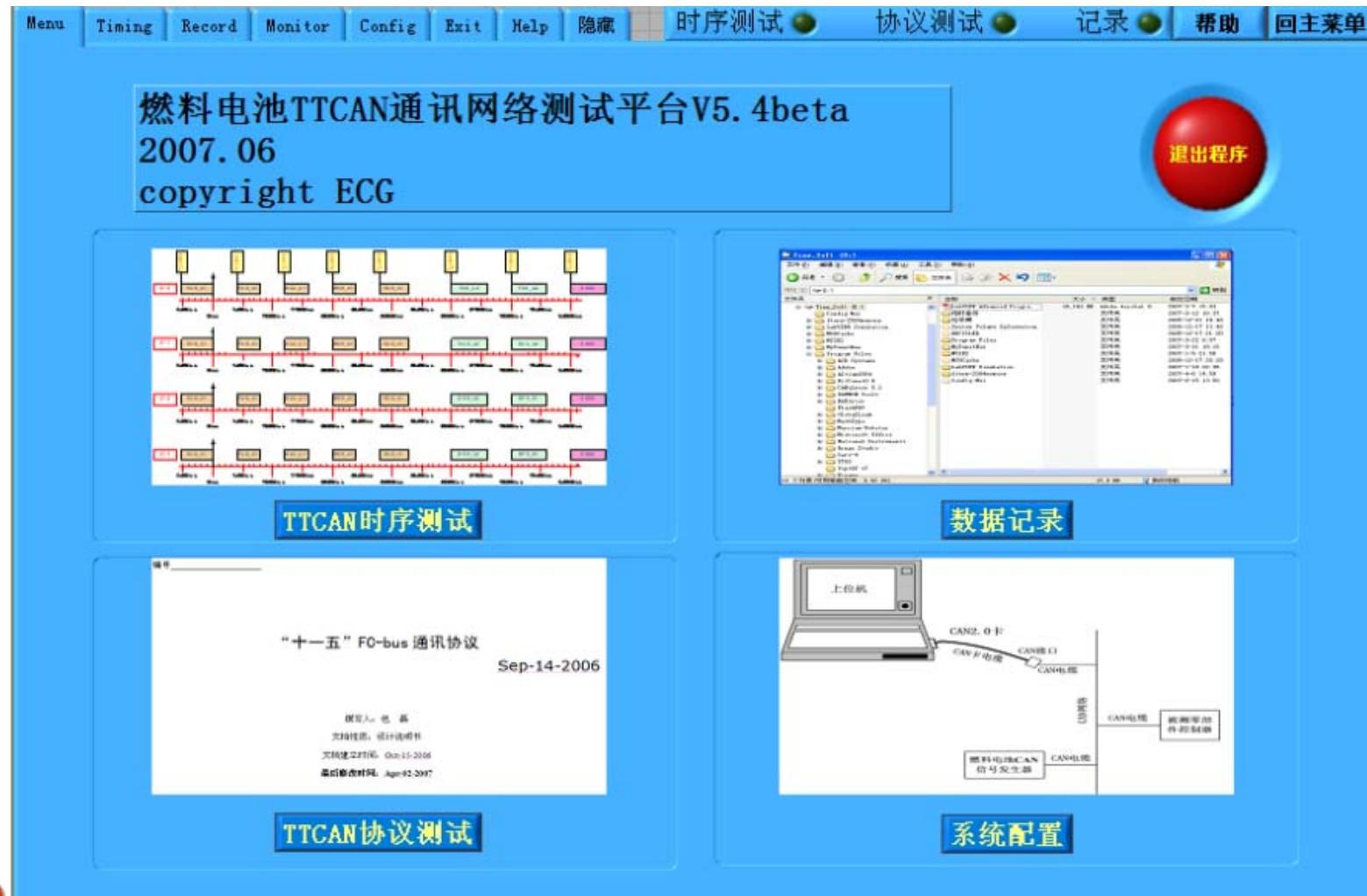
● TT CAN Tester





The Inner Vehicle Network Design

● TTCAN Tester Interface



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The Inner Vehicle Network Design

- Record the TTCAN messages, store the data





The Inner Vehicle Network Design

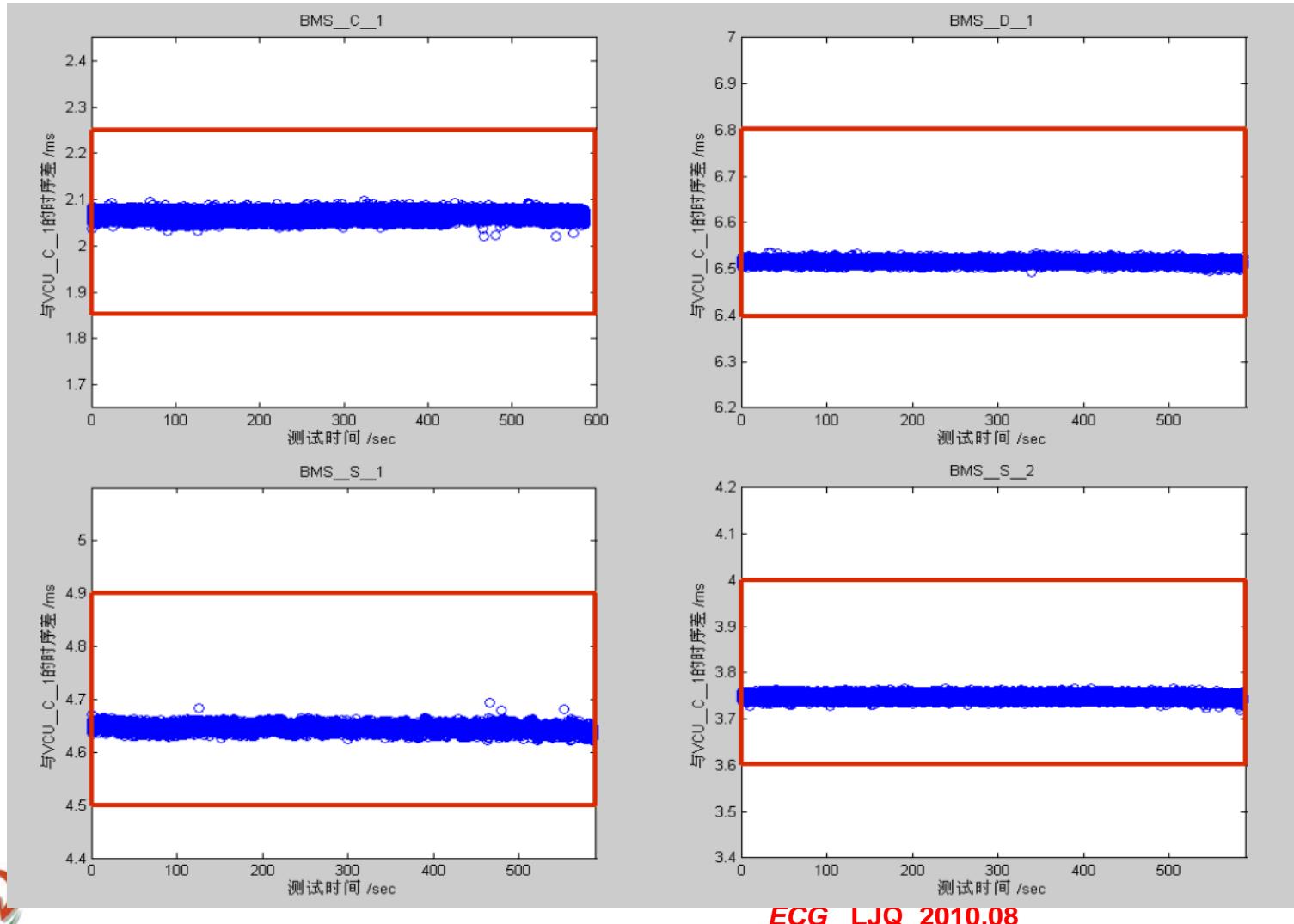
- Simulate partial of all nodes' messages, simulate abnormal states





The Inner Vehicle Network Design

◆ Measured TTCAN message Timing data: Red Curve is acceptable timing threshold band.





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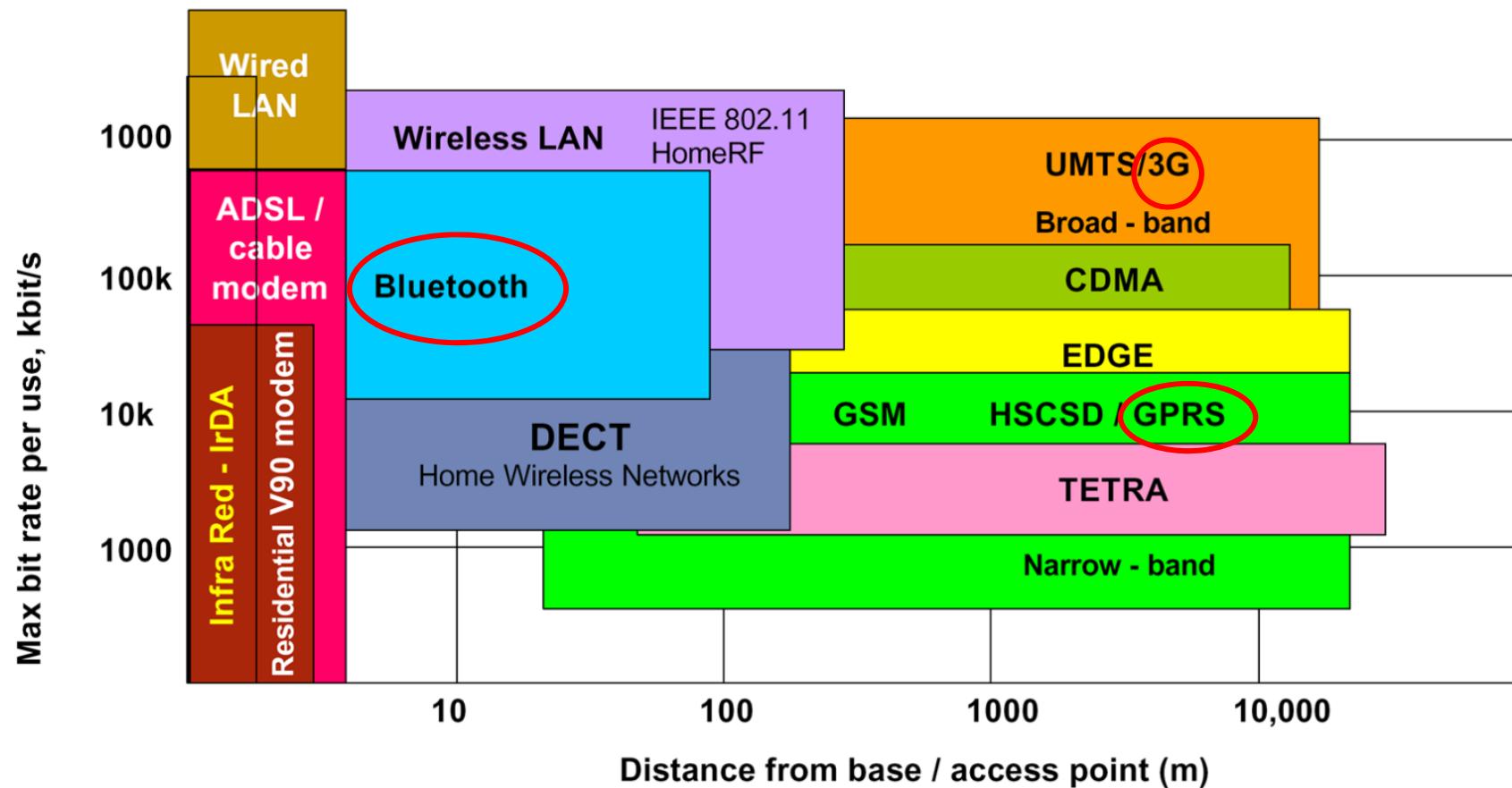
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The Wireless Communication Protocol

● Wireless communication



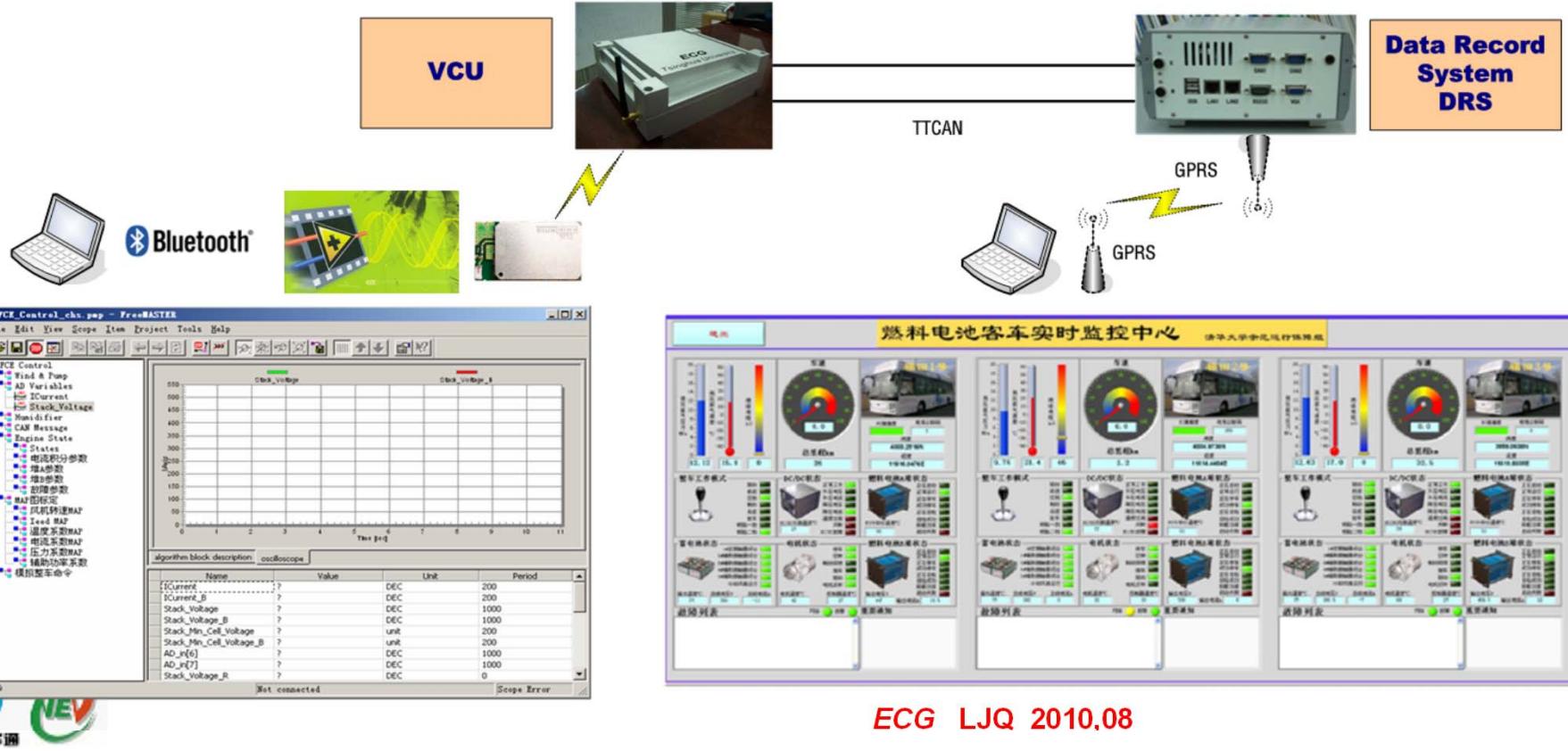


The Wireless Communication Protocol

Inter vehicle network: Bluetooth and GPRS

GPRS: Remote Monitor

Bluetooth: Short Distance Vehicle Wireless Monitor



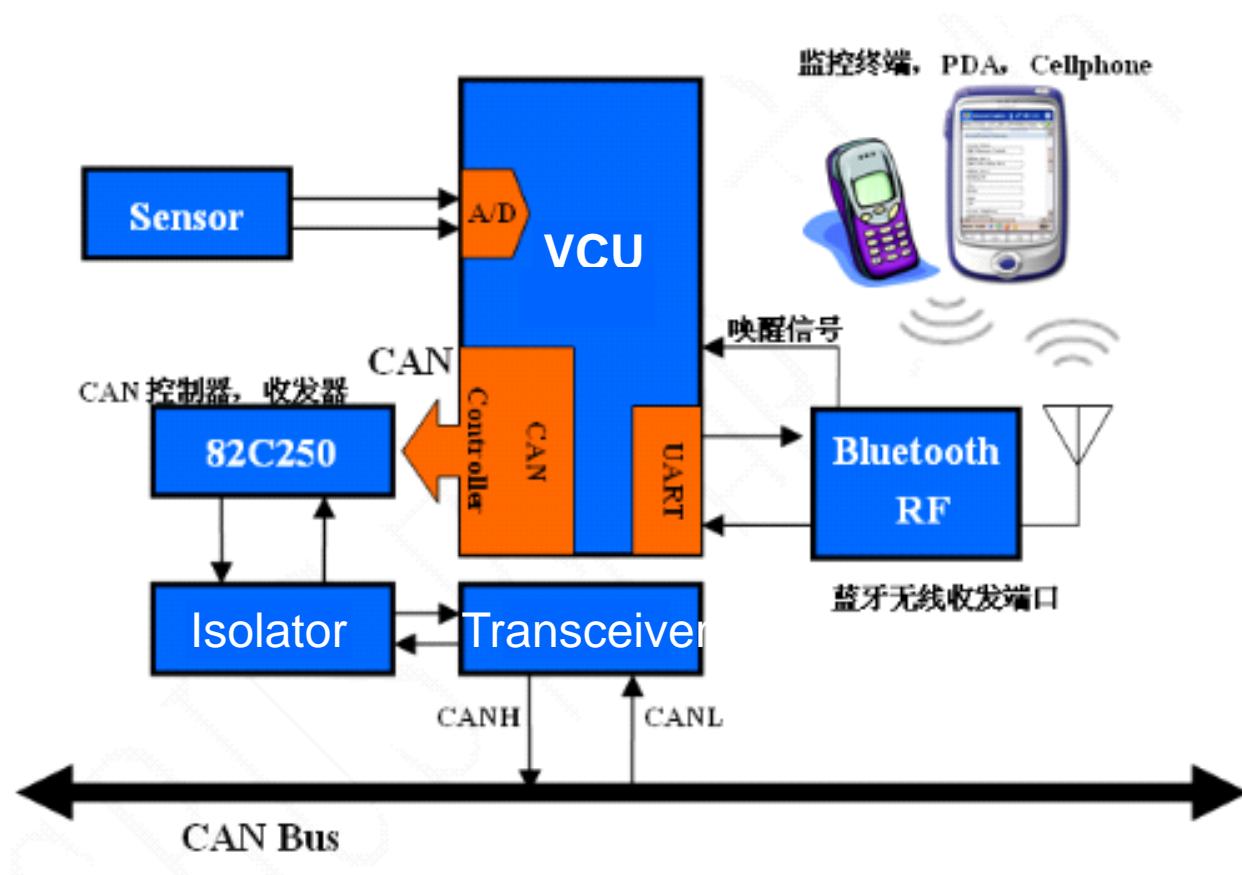
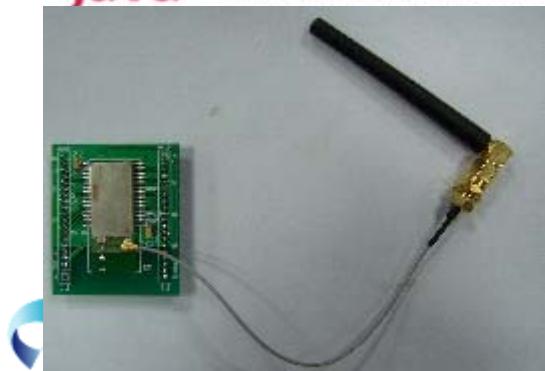


The Wireless Communication Protocol

- LabView based VCU monitor interface
- PCMaster based VCU monitor terminal
- Bluetooth and J2ME Mobile phone monitor terminal
- In System Programming based on Bluetooth



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are used under license and are tradere
SPARC International, Inc. in the U.S. a
Acquisitions: Commercial Software ->
Standard License Terms and Condition





The Wireless Communication Protocol

- Available functions:

- ◆ Monitor the VCU by computer via Bluetooth—Plugless—safety and any place around the vehicle
- ◆ Debug the VCU by computer via Bluetooth
- ◆ Monitor and diagnose the VCU by using mobile phone via bluetooth
- ◆ Program or update the VCU software via bluetooth-ISP



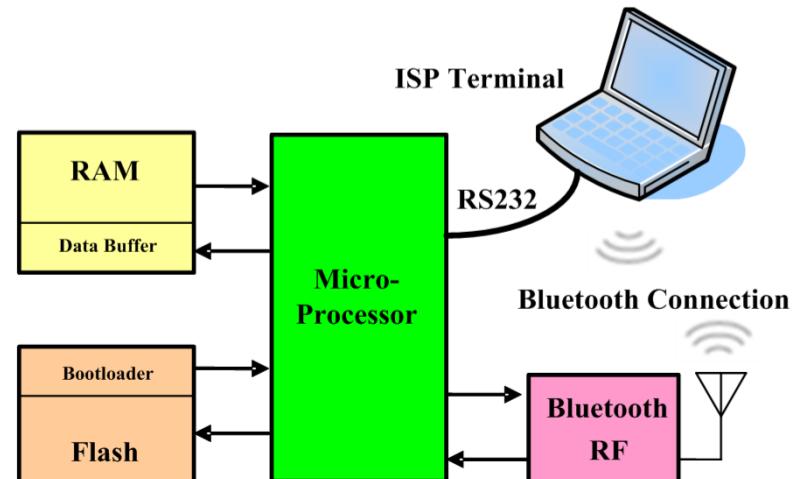
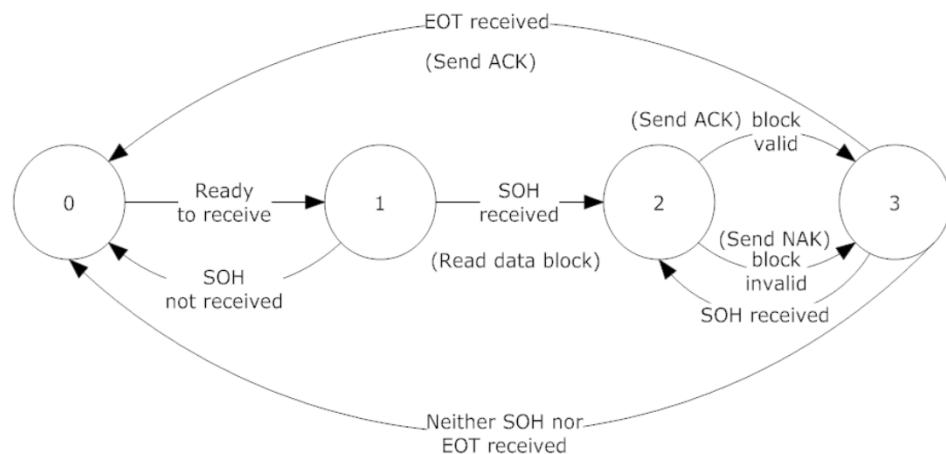
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The Wireless Communication Protocol

● Wireless ISP

The data and program code safety can be several code check algorithm, it is very convenient when on-vehicle debug.

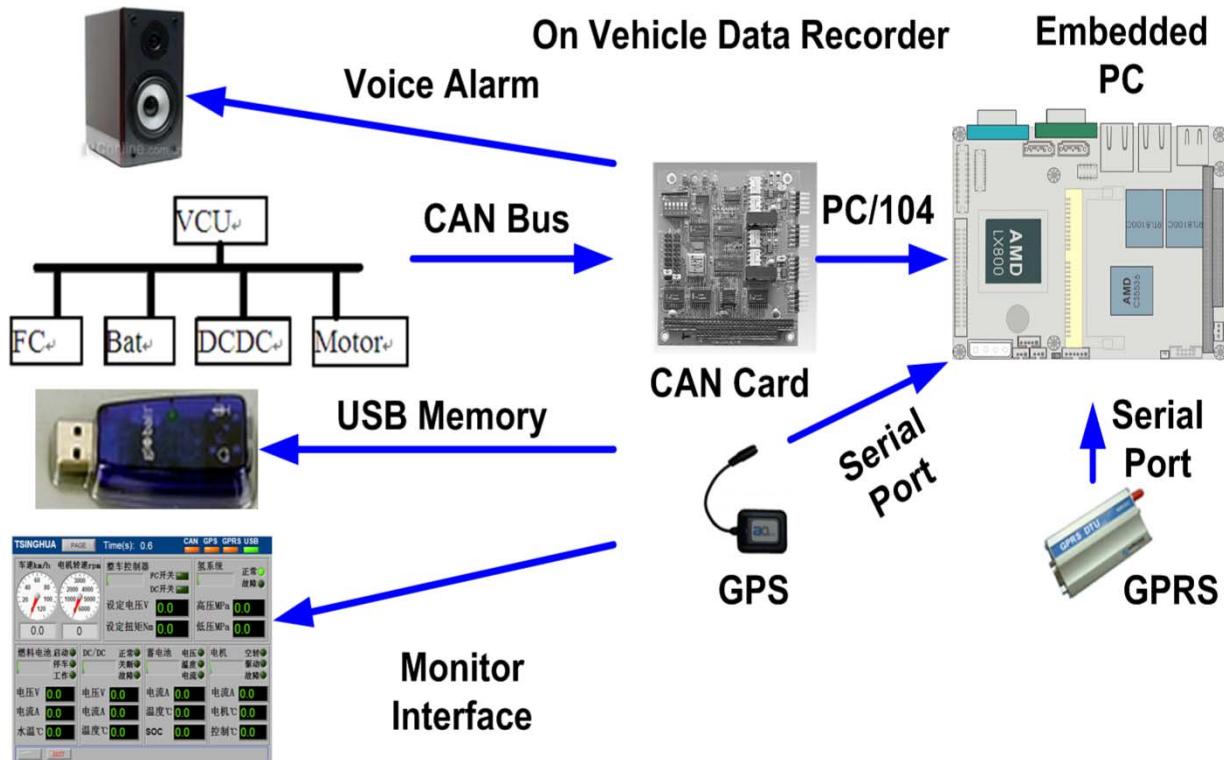




The Wireless Communication Protocol

● Data record system

- ◆ WinCE embedded PC with communication card,
- ◆ Functions:
 - Record all TTCAN messages, Diagnosis and alarm, GPS, GPRS
 - USB for data storage: Fast record (10ms) , short period, several days, <1 month.





The Wireless Communication Protocol

- Data record: WinCE with embedded PC





The Wireless Communication Protocol

● On vehicle display interface



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The Wireless Communication Protocol

- On vehicle display interface

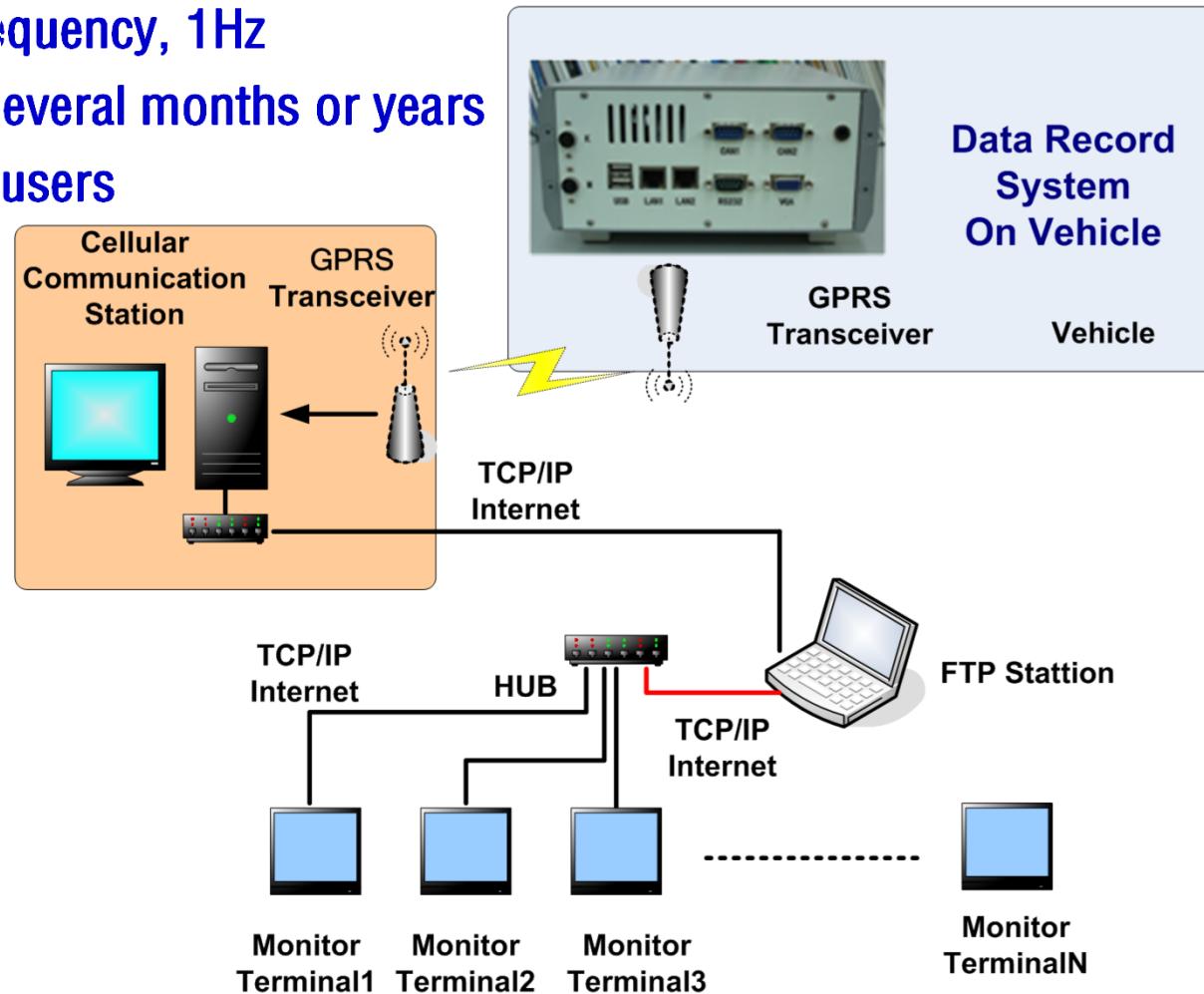
时间	总时间	目标DC/DC电流	目标DC/DC电压	目标转矩	燃料电池开关	控
制蓄电	电池开关	DC/DC控制模式代码	通讯帧序号代码	整车工作模式	燃料电池	燃料
功率	整车控制器状态标志	高压氢气压力	低压氢气压力	高压氢气温度	电池温度	电池目
压氢气	温度	供氢系统LIFE值	氢系统状态标志位	燃料电池输出电压	燃料电池输出	标低
电流	电堆入口氢气压力	电堆入口空气压力	燃料电池状态标志位	燃料电池输出能力(电流)		
	电堆故障码 1#堆最低单片电压	1#堆平均单片电压	2#堆最低单片电压	2#堆平均单片		
电压	燃料电池冷却水温度	燃料电池Life	DC/DC输出电流	DC/DC输出电压		
	DC/DC控制标志位	DC/DC控制器life	DC/DC内部温度	环境温度	蓄电池总线	电
压	蓄电池充放电流	蓄电池模块SOC	蓄电池控制器life	蓄电池状态	蓄电池状态	电
池箱内	最高温度	电池模块平均电压	电池模块电压极差	电池模块平均温度	电池模块温度	温
极差	电机转速	电机控制器实际电流	电机输入电压	电机控制器life	电机实际转速	矩温
度	前管路制动气压	后管路制动气压	制动踏板	加速踏板	电机温度	统系
状态1	电机状态标志位1	电机状态标志位2	电机故障码	氢气供给系统状态0	氢气供给系统状态0	别统
	自检报警气瓶号	自检报警_故障码	氢气供给系统剩余气量	电堆诊断码	最高故障码	级康
度	燃料电池空气出口温度	燃料电池冷却水出口压力	制动能量回收	Ready	燃料电池健康	模模
	模块1-1最低单片电压	模块1-2最低单片电压	模块1-3最低单片电压	模块1-4最低单片电压	模块1-4最低单片电压	模模
块2-1最	低单片电压	模块2-2最低单片电压	模块2-3最低单片电压	模块2-4最低单片电压	模块2-4最低单片电压	模模
块1-1单	片电压方差	模块1-2单片电压方差	模块1-3单片电压方差	模块1-4单片电压方差	模块2-4单片电压方差	模模
块2-1单	片电压方差	模块2-2单片电压方差	模块2-3单片电压方差	模块2-4单片电压方差	模块2-4单片电压方差	模模
缘电阻Rf	车速	整车辅助功率	PWM占空比1	PWM占空比2		
	PWM占空比3	PWM占空比4	ABSActive	燃料电池电堆氢气消耗率		
车控制系统状态	车辆航向	车辆经度	车辆纬度	车辆速度(GPS)		
驶里程	总行驶里程	USB状态	GPS状态			
行驶里程CAN状态					计算车速	整行



The Wireless Communication Protocol

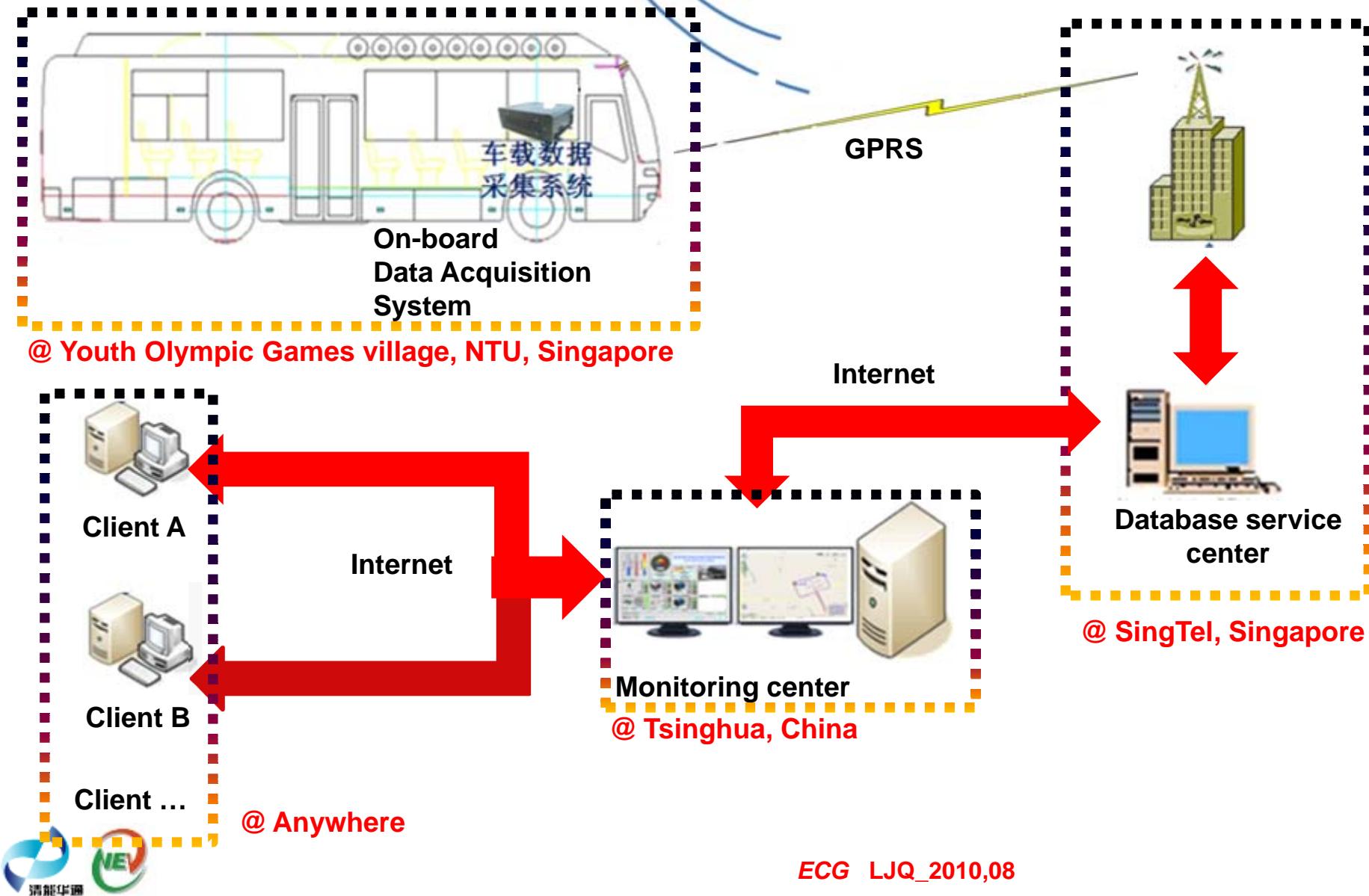
● Remote monitor of Electric Vehicle

- ◆ Low update frequency, 1Hz
- ◆ Long period, Several months or years
- ◆ Multiple client users





Remote Monitor System

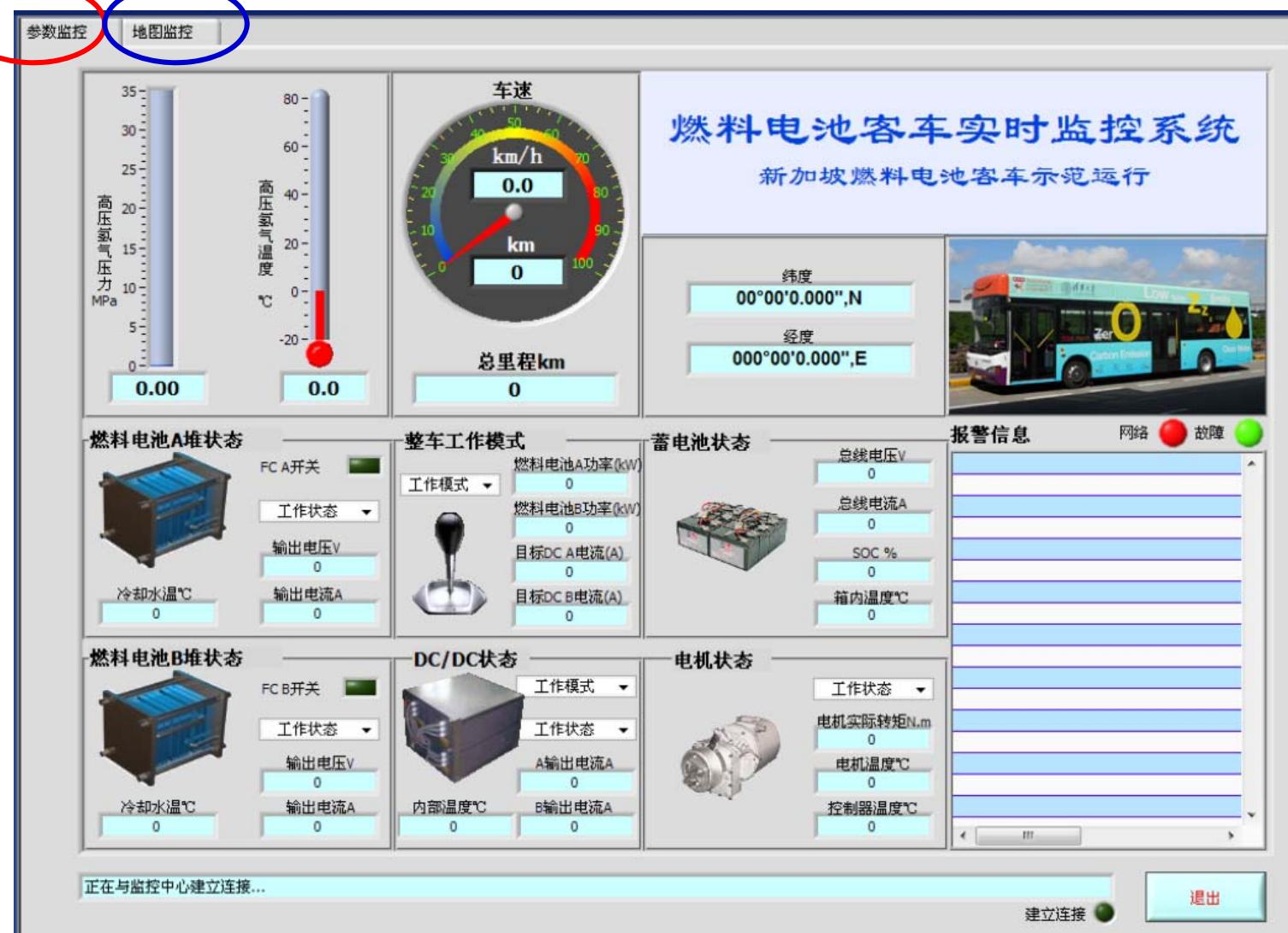




The Wireless Communication Protocol

Parameter Monitoring

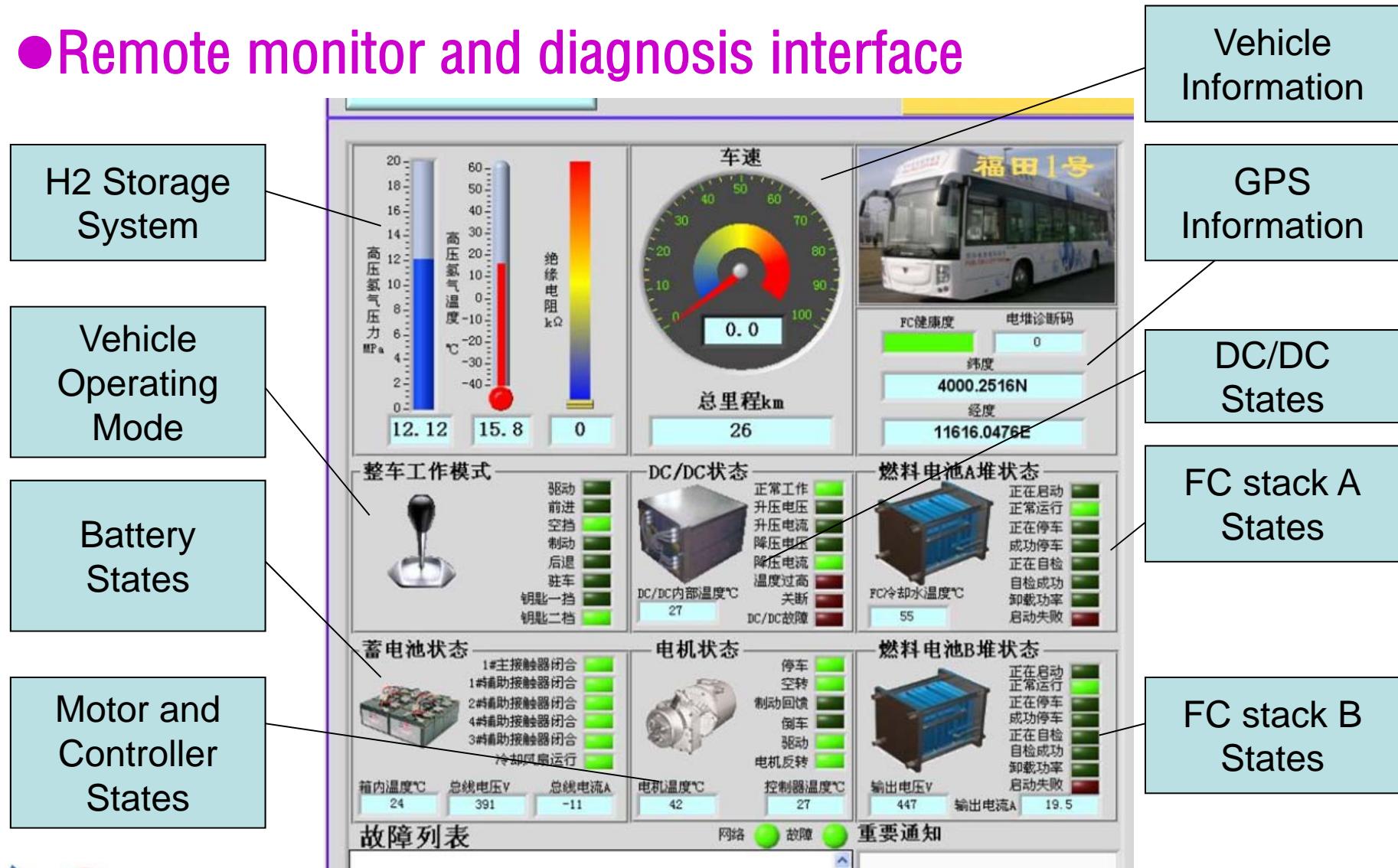
MAP Position Monitoring





The Wireless Communication Protocol

● Remote monitor and diagnosis interface





The Wireless Communication Protocol

● Remote monitor and diagnosis interface

- ◆ The powertrain state of each FC bus can be monitored in the lab.



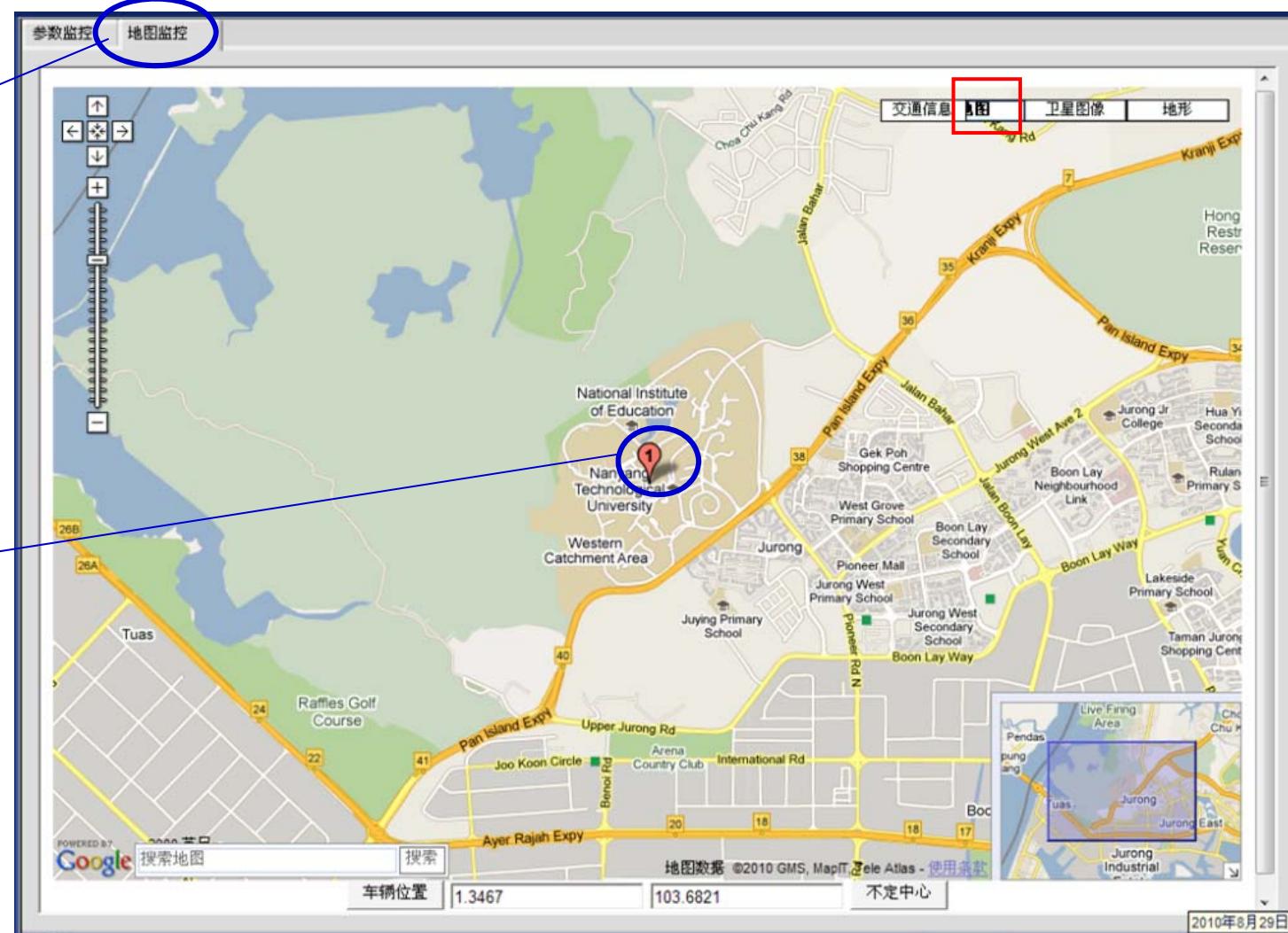
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The Wireless Communication Protocol

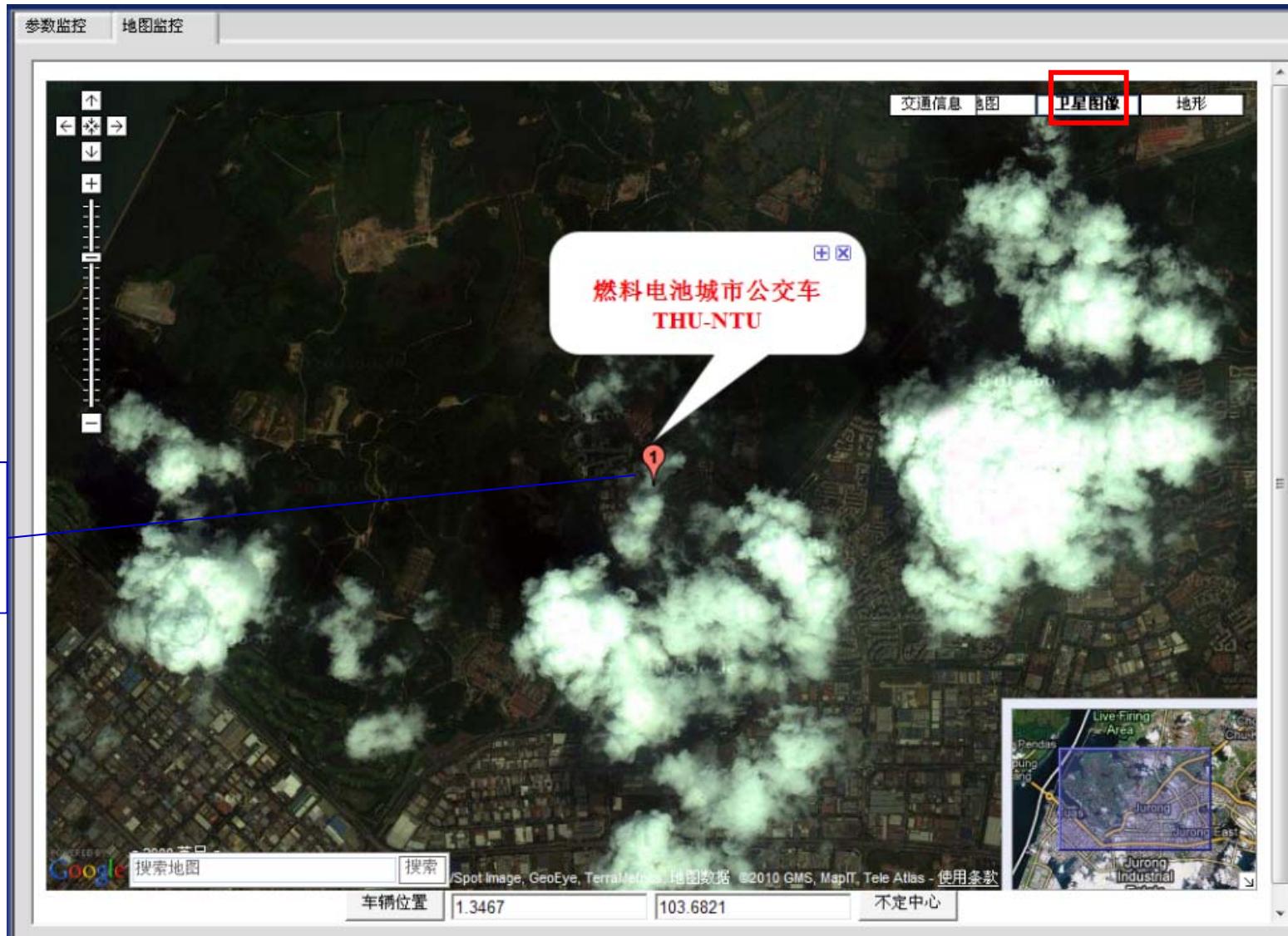
MAP
Position
Monitoring

Current
Vehicle
Position





The Wireless Communication Protocol



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Demonstrations and Conclusions

Demonstrations and Tests

- The network stable during demonstration and test,
- TTCAN and Bluetooth is suitable for calibration and testing the vehicle performance during development.
- Remote monitor system is very useful for fleet data collection, diagnosis, and maintenances.





Demonstrations and Conclusions

Olympic Marathon Game



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Demonstrations and Conclusions

Olympic Marathon Game





Demonstrations and Conclusions

30. Jul. 2009: Finished one year demonstration

3 Buses: Total 60,000 km

Total 20 faults/60,000km = 1 fault/3000km





Demonstrations and Conclusions



Demonstration in Singapore



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The End.

Thank you for your attention!

Questions?