Bluetooth Serial Modem Prototype

1. Objectives and Product Specification

Scope
Sponsored by Itron Australasia, this thesis took an unorthodox approach by implementing the product development cycle in the creation of a Bluetooth product, relevant to Automatic Meter Reading. The project objectives were as follows:

• To design, implement and test Bluetooth enabled, modem-like devices capable of performing a point-to-point serial cable emulation.
• To do a high level design of the embedded application which will implement the emulation and permit control via AT commands.

Requirements Definition & Product Specifications
The above objectives were encompassed by the functional and non-functional specification, which were formulated at the outset to guide the project. Goals defined during this early stage included:
1. Target Range: 100m
2. Target throughput: 100kbps
3. Control via AT commands
4. Power supply versatility
5. Diminutive size (W<33mm)
6. Interoperability as per the SPP

2. High Level Design

Hardware and software sub-systems were then identified, and interface signals defined, with design split into hardware & software.

Hardware
Five subsystems were defined, according to the following diagram.

Software
The software architecture consisted of the legacy dialler application, Bluetooth protocol stack & the cable emulation application. With the former two implemented as HyperTerminal and BlueStack respectively, only the cable emulation application needed creation. The subsystem partitions in the system protocol stack are shown below:

3. Low Level Design

All subsystems were rigorously designed in PROTEL, with some of the more complex sub-systems based on CSR reference designs. Class one and two radio operation was entirely dependent on the radio sub-system, of which two designs were created for incremental implementation. The Bluetooth sub-system was based on the BlueCore02-Ext Bluetooth transceiver IC which boasts a 16-Bit RISC processor plus dedicated hardware for all Baseband functionality.

Software low level design was based on numerous CSR example designs which were merged and modified to realise the cable emulation. Implementation of AT commands however, was left to another team member as it was outside the scope of this thesis.

4. Implementation

A three phase approach was taken to hardware implementation, culminating in a long-range, class one prototype. The prototypes, shown below, incorporated various Bluetooth modules to implement the radio and Bluetooth subsystems, avoiding complexities associated with RF design. Additionally, a “Serial Peripheral Interface Blaster” was constructed, enabling the prototypes to be reprogrammed and firmware to be altered through a standard LPT port.

5. Testing & Performance Evaluation

Numerous tests were carried out to determine conformance with the specification. Metrics quantified included page & inquiry delays, throughput, range, BER and power consumption. Throughput and connection delay as a function of distance (in meters) are shown below:

6. Conclusion & Recommendations

Although the cable emulation was successful and all non-functional specifications were met, the experimental range was only 20-25m, with an average throughput of 55kbps (although up to 80kbps was observed).

The former was due to poor antenna positioning of the module on the PCB and the fact that the module was only qualified at 15 instead of 20dBm. The former could be improved by repositioning the module as in (a) or implementing a λ/4 dipole antenna as in (b), using a module without an on board antenna.

Limited throughput was due to the performance hit imposed by running the cable emulation on the BlueCore's RISC processor, which reduced throughout by up to 40%. This could be improved by experimenting with different libraries used by the cable emulation or just waiting for the release of the BlueCore03, which would surely feature improved processing power. Finally, cost & space savings could be achieved without using a module, as shown in (c).