A REAL-WORLD SYSTEM COST MODEL FOR OFF-PREMISES SUBSCRIBER EQUIPMENT

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ABSTRACT

Off-premises subscriber equipment is either now available or under development by several manufacturers. This equipment includes outdoor addressable converters, taps, traps and jammers, applications for which are predicated on a growing need to minimize the electronic equipment inside the subscriber's home -- not only to increase signal security, but to reduce system maintenance and pay channel churn.

This paper presents a unified analysis of a fragmented and multi-faceted emerging technology. It proffers a simple and accurate method of estimating total system costs required in the use of off-premises subscriber equipment and presents a model that allows a direct relation between equipment costs and system costs applicable to all known off-premises devices.

There has been little or no means of providing a consistent comparison between the various manufacturers' products on a cost-per-subscriber basis. Presently, manufacturers can provide equipment pricing either for fully loaded (100 percent penetration), or partially loaded configurations, i.e., prices for a "common" housing, chassis, etc., and plug-in subscriber modules. However, these equipment costs cannot be related to the system cost without an actual model.

The model presented here is based on actual port usage, employing statistics from Jerrold's installed base, in order to arrive at a probability density function. It is applicable to any off-premises subscriber device and provides for an estimation of system costs and a comparison of competitive technology. The model has undergone extensive testing by application to actual systems presently under design.

SOME BROAD GENERALITIES

It is popular these days to consider technical approaches that would remove the set-top converter from the subscriber's home.

The two main reasons given for wanting to do this are to minimize the operator's investment within the home and to maximize signal security. Both of these perceived needs are of particular interest for application to the big cities; in particular, where lower economic scaled people are concentrated, thereby conjuring up visions of high churn, difficulty in maintenance, equipment theft and inability to audit installations.

The ideal is to provide all electronics off-premise within an "off-premise device" (OPD) in locations having unrestricted access by operators, with the only operator investment at the home being drop cable, ground block and an F-connector. This ideal can be rapidly compromised by consideration of the need for subscriber powering, channel selection and conversion for non-cable ready TVs. When features such as parental control, impulse-pay-per view, remote control and remote volume control are included, then the investment within the home can no longer be considered minimized, although it should still be less than a conventional scrambled addressable set-top based system. The cost per subscriber of the in-house electronics (IHE), however is a known entity, unlike, as is shown later, that of the OPD.

The signal security ideal can also be severely compromised with off-premise devices, especially if unscrambled premium signals are available on feeder lines up to the OPD. This is because high density housing provides plenty of opportunity for impossible-to-audit pressure taps and, not attempting to coin a new term, CPTTV, or Community Pressure Tap Television where enterprising pressure tappers can provide for locally operated distribution of the clear signals.

OPD TECHNIQUES

There are currently three generic techniques associated with off-premises devices. All of which are head-end addressable.

Off-Premise Converters

Here, the RF signal conversion electronics is placed within the OPD and the subscriber control unit within the IHE. One converter is needed for each TV or VCR. The drop cable is no longer broadband multichannel, but now only supports one channel per TV or VCR. Present technology provides for multiplexing of two channels (plus FM band) per drop, with no real technical reason for not increasing to three or more per drop. The drop lengths are dependent on powering, not bandwidth.

Addressable Traps - Filtering Method

This technique provides for addressable channel rejection filters (traps) for premium channels or tiers. The drop cable is broadband and all but the rejected channels are available to all subscriber TVs or VCRs. The IHE contains the subscriber control plus converter, the latter of which is normally plain but could also include a descrambler at higher IHE cost. The drop length can be limited by either subscriber powering or bandwidth.

Addressable Traps - Jamming Method

This technique uses an addressable jammer to jam premium channels or tiers. The drop cable is broadband and all signals are available to all subscriber TVs and VCRs. However, those that are jammed are useless. The IHE contains the subscriber control plus converter, plain or with descrambler.

OPD DESIGN

The OPD must contain head end addressable hardware, power supplies, microprocessor memory, signal splitting, etc., regardless of which of the three technologies is chosen. This "common electronics" portion together with the known requirements for surge protection, RFI seal, weather seal, feeder line through loss, etc., essentially dictates that the OPD equipment cost on a per port basis is minimized when the common electronics cost is distributed over the maximum number of subscriber ports. For this reason, equipment concepts of up to 32 ports have emerged with 8 and 16 ports being typical. Another typical feature is plug-in modularity, organized on a per port basis with the philosophy being to plug in subscriber modules on an as-installed basis, and assumedly, to pluck them out on an as-disconnected basis.

OPD SYSTEM COST MODEL

In other words, in order to implement an OPD-oriented system in the most economical way, a non-conventional system design configuration must be used. The design would be different for each of the three OPD technologies mentioned previously, but is, in general, characterized by more ports per housing, fewer housings and longer drop lengths than conventional tap (i.e., two, four or eight port) system approaches.

Since fewer housings are needed and each OPD contains RF gain, the through-line feeder insertion loss can be minimized so that fewer line extenders are needed. However, more power supplies or more power capability may be needed, even though fewer line extenders are used, to power all or part of the OPD electronics itself.

Of course, the problem with any non-conventional system design is that if for any reason things don't work out in the long run, the entire feeder system must then be rebuilt in order to revert to a set-top converter approach with conventional taps. Over the years, several manufacturers have standardized the various tap sizes and values so that multiple sources exist. Off-Premises Device technology, however, has not yet been standardized and the manufacturers currently involved have each come up with significantly different approaches that require different system designs. Each offerer has their own design rules, which apparently are chosen to minimize system cost for comparison purposes. However, in order to compare OPD technologies, at least a sample of each system has to be designed for all OPD approaches under consideration.

THE CONVENTIONAL MODEL FOR OPD DESIGN

For the reasons cited above, what is proposed in this paper is to apply all OPD approaches to a conventional (tap plus set-top) system model, for comparison purposes. This is totally real world (assuming clearances) for the upgrade market application and is not improper for the new build and rebuild applications, for those operators who do not want to accept the risk of forced rebuild in the event something goes wrong.

A reasonable approach would be to design the system using conventional two, four and eight-way taps. Then cost out the application of the OPD corresponding to those tap sizes.

From Jerrold historical records, the tap distribution in the United States is 36% two-way, 43% four-way and 21% eight-way. That's what is out there now based on one port per home passed.

Before we can crank out the numbers, however, there remains one burning question involving the OPD technology of off-premise converters: how many ports per home passed? Or how many TVs and VCRs are going to be in each home at any time during the next 20 years? If you pick a number too low and design to it, then higher penetration could mean system redesign or at least splicing in of more housings. Pick a number too high and the system's initial cost becomes prohibitive. And no number is right; one block may have homes wanting cable with three TVs and two VCRs each and the next block may not subscribe. There is no answer to this one, but some designers use three ports per home and hope for the best.

Since the intention is to replace conventional taps with addressable OPDs, it is important that the probability of port usage for each tap size be entered into the model. This would naturally depend upon penetration; for a perfectly designed system, all tap ports would be used at 100% penetration. At a typical 55% penetration, we can expect that about half of the available tap ports are in use for each tap size. Most two-way taps have one connection, most four-way have two and most eight-way have four or five, per the probability distribution breakdown shown in Table 1. The composite probability is the probability of having some number of connections in use for a tap of <u>any</u> size, for example, 5% of the total taps out there are two-ways with two active connections and 18% are four-ways with two active connections, for a composite of 23% of taps with exactly two connections.

TABLE 1

SYSTEM SUBSCRIBER TAP
PROBABILITY DENSITY FUNCTION

| PROBABILITY OF CONNECTED SUBSCRIBERS |

SUBS PER HOUSING	2 WAY	4 WAY	8 WAY	COMPOSITE	AVERAGE SUBS PER TAP
0	.12	.03	---	.15	---
1	.19	.08	---	.27	.27
2	.05	.18	---	.23	.46
3		.10	---	.10	.30
4		.04	.01	.10	.40
5			.094	.094	.47
6			.04	.04	.24
7			.01	.01	.07
8			.006	.006	.05
TOTALS	.36	.43	.21	1.00	2.26

NOTE:

AVERAGE SUBS PER TAP HOUSING LOCATION = 2.26

AVERAGE PORTS PER TAP HOUSING LOCATION = 4.12

CALCULATED AVERAGE SUBSCRIBER PENETRATION $= \frac{2.26}{4.12}$ 55%

EQUIPMENT COST

We can now apply the composite subs-per-tap factor to price out the system, under the rule of having to place the OPDs at the exact locations where two, four or eight-way taps would be placed in a conventional system. To do this, we need to price the OPD equipment out depending upon the ports used. Consider three cases:

Case 1: Equipment designed with minimum use of common electronics with almost all electronics dedicated to each subscriber drop module. The housing and common electronics is priced at $80, with $120 per subscriber module, assumed to be plugged in on an as-required basis.

Case 2: Equipment designed with maximum use of common electronics and relatively little dedicated to the subscriber drop module. The housing and common electronics is priced at $250, with $25 per subscriber module, assumed to be plugged in on an as-required basis.

Case 3: Same equipment as Case 2 except that the subscriber modules for the two, four and eight port OPDs are plugged in on initial system turn-on.

TAPS USED	CASE 1		CASE 2		CASE 3	
	TOTAL	PER SUB	TOTAL	PER SUB	TOTAL	PER SUB
0	$ 8	$ 0	$ 8	$ 0	$ 8	$ 0
1	200	200	275	275	300	300
2	320	160	300	150	300	150
3	440	147	325	108	350	116
4	560	140	350	88	350	88
5	680	136	375	75	450	90
6	800	133	400	67	450	75
7	920	131	425	61	450	64
8	1040	130	450	56	450	56

CASE 1 $80 Common plus $120 plug-in module per sub.

CASE 2 $250 Common plus $25 plug-in module per sub.

TABLE 2

EQUIPMENT PRICING EXAMPLES

The prices given represent hypothetical situations and are not intended to represent any particular manufacturer or technology. Since there are no standards, it would not be surprising if the manufacturer of the Case B equipment would advertise a $56 per subscriber unit "less than half the price of his competitor", the Case 1 manufacturer. However, the systems are essentially equal in price.

The fact that Case 1 and Case 2 system cost is identical can be shown by applying the density function to the pricing examples to result in Table 3. In this model, both cases are about $139 per subscriber, in contrast to prices of $130 and $56 that are based on the fully loaded eight-way OPD (which occurs in 0.6% of the situations for conventional eight-way taps).

Case 3 further tells us that fully loading the OPD prior to subscriber connections only costs $9 per subscriber more than Case 2 equipment. The same exercise applied to Case 1 results in a $185 per subscriber price, however, about $45 higher for this mode of installation.

Both installation techniques and all three cases can be reduced to simple formulas, requiring as input only the cost data for the housing (common electronics) and subscriber module, as shown in Table 3.

TAPS USED	COMPOSITE DISTRIBU-TION FACTOR	AVERAGE SUBS PER TAP	CASE 1 SELL PRICE	CASE 1 PRICE PER SUB	CASE 1 PRICE PER SUB XPDF	CASE 2 SELL PRICE	CASE 2 PRICE PER SUB	CASE 2 PRICE PER SUB XPDF	CASE 3 SELL PRICE	CASE 3 PRICE PER SUB	CASE 3 PRICE PER SUB XPDF
0	0.15	----	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
1	0.27	0.27	200	200	54.00	275	275	74.25	300	300	81.00
2	0.23	0.46	320	160	36.80	300	150	34.50	300	150	34.50
3	0.10	0.30	440	147	14.67	325	108	10.83	350	116	11.67
4	0.10	0.40	560	140	14.00	350	88	8.75	350	88	8.75
5	0.094	0.47	680	136	12.78	375	75	7.05	450	90	8.46
6	0.04	0.24	800	133	5.33	400	67	2.67	450	75	3.00
7	0.01	0.07	920	131	1.31	425	61	0.61	450	64	0.64
8	0.006	0.05	1040	130	.78	450	56	.34	450	56	.34
TOTAL	1.00	2.26			$139.67 PRICE			$139.00 PRICE			$148.36 PRICE
FORMULA					0.47H + 0.85M = PPS H = 80 M = 120			0.47H + 0.85M = PPS H = 250 M = 25			0.47H + 1.23M = PPS H = 250 M = 25

TABLE 3

MODELED COST PER SUBSCRIBER

CONCLUSION

Operators contemplating off-premise subscriber equipment should be very careful when deciding system configuration and should consider using conventional system architecture to avoid the possibility of getting stuck with a special system for which rebuild is the only option. Accordingly, systems using off-premise equipment should be priced out using conventional system (tap and set-top converter) design rules. The examples given show that only a consistently and properly weighted per-subscriber equipment cost should be considered, which is generally significantly different than that of the improbable fully-loaded equipment.