

Consumer Driven System Level Requirements																
Consumer Expectations	Importance	Proven Interoperable Protocol	Accepted Technology in Marketplace	Acceptable Cost trade offs	Easy to provision to HAN / Plug and Play Appliance	Minimize Enabling Infrastructure	Technology Supply Chain Exists	Forward / Backward compatibility / Future proof	Interference and Noise Handling	Easy System Operation	Easy to Maintain	Easy to Replace	Robust messaging capability	Affordable to install	Security Mechanisms	Total
Easy to Install	3	h	h	h	h	h	h	h	h	h	m	m	l	h	h	75
Easy to Use	3	h	h	h	h	h	h	m	h	h	h	h	l	l	l	63
Interoperable	3	h	h	h	h	h	h	h	h	h	h	h	l	l	m	69
Reliable Operations	3	h	h	h	m	h	m	l	h	h	l	l	l	l	h	39
No Compromise of Privacy	5	m	m	m	m	l	m	h	l	l	l	l	l	l	h	65
Low Security Degradation	5	m	m	m	m	l	m	h	l	l	l	l	l	h	h	105
No Compromise to Safety	5	m	m	m	m	l	m	h	l	l	l	l	l	l	h	65
Results																
Easy to Install	3	27	27	27	27	27	27	27	27	27	9	9	3	27	27	75
Easy to Use	3	27	27	27	27	27	27	9	27	27	27	27	3	3	3	63
Interoperable	3	27	27	27	27	27	27	27	27	27	27	27	3	3	9	69
Reliable Operations	3	27	27	27	9	27	9	3	27	27	3	3	3	3	27	39
No Compromise of Privacy	5	15	15	15	15	5	15	45	5	5	5	5	5	5	45	65
Low Security Degradation	5	15	15	15	15	5	15	45	5	5	5	5	5	45	45	105
No Compromise to Safety	5	15	15	15	15	5	15	45	5	5	5	5	5	5	45	65
TOTALS		153	153	153	135	123	135	201	123	123	81	81	27	91	201	
WEIGHTING TO NEXT LEVEL		3	3	3	3	3	3	9	3	3	1	1	1	1	9	

ASSOCIATION OF HOME
APPLIANCE MANUFACTURERS

System Requirements Mapped to Technology Requirements

[illegible]

Results

[illegible]

[illegible]

AHAM Assessment of Communication Standards for Smart Appliances

System Requirements		Importance	Relative category weight	SEP 2.0	OpenADR	BACnet / ISO 16484-5	BACnet ASHRAE 135-2008	LON ANSI 709 1-B-2002	IEC 62056 / DLMS	ISO/IEC 15067-3	OPC-UA	Zwave	ZigBee SEP 1.0	Total
1	Proven Interoperable Protocol	3.00												145
	IEC CIM compliant	3.00	0.13	h	l	m	m	l	l	l	l	l	l	8
	Network Interface exists	3.00	0.13	h	h	m	m	l	h	m	h	h	l	21
	Loose coupling	3.00	0.13	h	m	h	h	m	h	m	m	m	l	20
	Certification Bodies / Test Labs Exist	3.00	0.13	h	l	l	l	h	h	l	h	h	h	22
	Commercial Alliance Supported / Vetted	3.00	0.13	m	h	m	m	m	h	l	h	h	m	20
	Open Specification	3.00	0.13	m	l	m	m	m	m	m	m	l	m	10
	On the NIST Interoperability Roadmap	3.00	0.13	h	h	m	m	m	m	h	m	m	l	17
	SDO supported / vetted	3.00	0.13	m	h	h	m	m	h	h	h	h	m	25
2	Accepted Technology in Marketplace	3.00												138
	Current installed base	3.00	0.33	l	h	h	h	h	h	l	l	h	h	66
	Technology currently in use in Non-HAN systems	3.00	0.33	l	m	m	m	m	h	l	m	h	h	44
	Technology currently in use in HAN systems	3.00	0.33	l	l	l	l	m	l	l	l	h	h	28
3	Acceptable Cost trade offs	3.00												136
	User configuration method exists w/o additional hardware	3.00	0.33	m	h	h	h	m	h	h	l	l	m	56
	Pre-configurable	3.00	0.33	h	l	l	l	h	l	m	m	l	m	32
	Standard Implementation Complexity	3.00	0.33	m	h	m	m	m	h	m	m	h	m	48
4	Easy to provision to HAN / Plug and Play Appliance	3.00												146
	Supports adding, deleting, modifying of devices	3.00	0.33	h	l	h	h	h	m	h	h	h	h	76
	Supports multiple appliances	3.00	0.33	h	m	h	h	h	l	h	h	h	m	70
5	Minimize Enabling Infrastructure	3.00												150
	Application requires additional hardware	3.00	0.50	h	m	h	h	l	m	h	l	h	m	84
	Application requires additional software	3.00	0.50	l	l	h	h	l	l	h	l	h	m	66
7	Forward / Backward compatibility / Future proof	9.00												330
	Supports authorized direct load control	9.00	0.17	h	h	l	h	l	m	h	l	m	l	69
	Supports time-based power reduction/consumption	9.00	0.17	h	h	l	h	l	m	h	m	l	l	69
	Supports power reduction to reduce energy costs	9.00	0.17	h	h	l	l	l	l	h	l	l	l	51
	Supports third party load control	9.00	0.17	h	h	l	m	l	l	h	m	l	l	57
	Supports load shifting/optimization	9.00	0.17	m	h	l	l	l	l	h	l	l	l	42
	Supports independent power optimization	9.00	0.17	h	l	l	m	l	l	h	l	l	l	43
8	Interference and Noise Handling	3.00												108
	Auto recovery from Loss of Communication	3.00	0.33	h	m	l	l	m	l	l	h	m	l	32
	Supports Quality of Service (QoS) message prioritization	3.00	0.33	h	h	m	m	l	h	l	h	l	l	46
	Supports Lossy/low power communications	3.00	0.33	h	m	l	l	m	l	l	l	h	l	30
9	Easy System Operation	3.00												150
	Supports auto-discovery of devices	3.00	0.25	h	l	m	m	h	m	l	h	l	h	36
	Auto-installation	3.00	0.25	m	l	l	l	m	l	l	m	l	m	14
	Error Messages/Codes specified	3.00	0.25	h	h	h	h	h	h	l	m	m	h	53
	Protocol specifies error handling	3.00	0.25	h	m	h	h	h	h	l	h	m	m	48
10, 11	Easy to Maintain/Replace	1.00												30
	Software Upgrades can be installed by service technician	1.00	0.25	m	l	h	h	h	m	l	h	h	l	14
	Software Upgrades can be installed by consumer	1.00	0.25	m	l	l	l	l	l	l	h	m	l	6
	Firmware Upgrades can be installed by service technician	1.00	0.25	h	l	l	l	l	m	l	l	m	l	6
	Firmware Upgrades can be installed by consumer	1.00	0.25	h	l	l	l	l	l	l	l	m	l	5
12	Robust messaging capability	1.00												50
	Supports 2 way communications	1.00	0.20	h	h	h	h	h	h	h	h	h	h	18
	Supports general data queries	1.00	0.20	h	m	m	m	l	m	h	h	m	m	9
	Supports appliance specific queries	1.00	0.20	h	l	l	l	l	l	h	l	m	l	6
	Message verified with checksums/CRC algorithm/other	1.00	0.20	m	m	m	m	m	l	l	m	m	l	5
	Supports non-static message formats	1.00	0.20	h	h	m	m	m	m	h	h	m	h	12
14	Security Mechanisms	9.00												324
	Supports session encryption	9.00	0.33	h	m	m	m	m	m	l	h	m	h	138
	Supports user authorization	9.00	0.33	h	h	l	l	m	m	l	h	m	h	144
	Supports authentication	3.00	0.33	h	m	l	l	m	m	l	h	m	h	42
1	Proven Interoperable Protocol	3.00		20	16	13	11	10	20	11	17	17	8	145
	IEC CIM compliant	3.00	0.13	3	0	1	1	0	0	0	0	0	0	8
	Network Interface exists	3.00	0.13	3	3	1	1	0	3	1	3	3	0	21
	Loose coupling	9.00	0.13	3	1	3	3	1	3	1	1	1	0	20
	Certification Bodies / Test Labs Exist	9.00	0.13	3	0	0	0	3	3	0	3	3	3	22
	Commercial Alliance Supported / Vetted	9.00	0.13	1	3	1	1	1	3	0	3	3	1	20
	Open Specification	3.00	0.13	1	0	1	1	1	1	1	1	0	1	10
	On the NIST Interoperability Roadmap	3.00	0.13	3	3	1	1	1	1	3	1	1	0	17
	SDO supported / vetted	3.00	0.25	1	3	3	1	1	3	3	3	3	1	25
2	Accepted Technology in Marketplace	3.00		3	13	13	13	15	19	3	5	27	27	138
	Current installed base	3.00	0.50	1	9	9	9	9	9	1	1	9	9	66
	Technology currently in use in Non-HAN systems	3.00	0.50	1	3	3	3	3	9	1	3	9	9	44
	Technology currently in use in HAN systems	3.00	0.25	1	1	1	1	3	1	1	1	9	9	28
3	Acceptable Cost trade offs	3.00		15	19	13	13	15	19	15	7	11	9	136
	User configuration method exists w/o additional hardware	3.00	0.33	3	9	9	9	3	9	9	1	1	3	56
	Pre-configurable	3.00	0.33	9	1	1	1	1	9	1	3	3	1	32
	Standard Implementation Complexity	3.00	0.33	3	9	3	3	3	9	3	3	9	3	48
4	Easy to provision to HAN / Plug and Play Appliance	3.00		18	4	18	18	18	4	18	18	18	12	146
	Supports adding, deleting, modifying of devices	3.00	0.33	9	1	9	9	9	3	9	9	9	9	76
	Supports multiple appliances	3.00	0.33	9	3	9	9	9	1	9	9	9	3	70
5	Minimize Enabling Infrastructure	3.00		15	6	27	27	3	6	27	3	27	9	150

AHAM Assessment of Communication Standards for Smart Appliances

	Application requires additional hardware	3.00	0.50	14	5	14	14	2	5	14	2	14	5	84
	Application requires additional software	3.00	0.50	2	2	14	14	2	2	14	2	14	5	66
7	Forward / Backward compatibility / Future proof	9.00		72	69	9	39	9	15	81	15	12	9	330
	Supports authorized direct load control	9.00	0.17	13	13	1	13	1	4	13	1	4	1	69
	Supports time-based power reduction/consumption	9.00	0.17	13	13	1	13	1	4	13	4	1	1	69
	Supports power reduction to reduce energy costs	9.00	0.17	13	13	1	1	1	1	13	1	1	1	51
	Supports third party load control	9.00	0.17	13	13	1	4	1	1	13	4	1	1	57
	Supports load shifting/optimization	9.00	0.17	4	13	1	1	1	1	13	1	1	1	42
	Supports independent power optimization	9.00	0.17	14	2	2	5	2	2	14	2	2	2	43
8	Interference and Noise Handling	3.00		27	15	5	5	7	11	3	19	13	3	108
	Auto recovery from Loss of Communication	3.00	0.33	9	3	1	1	3	1	1	9	3	1	32
	Supports Quality of Service (QoS) message prioritization	3.00	0.33	9	9	3	3	1	9	1	9	1	1	46
	Supports Lossy/low power communications	3.00	0.33	9	3	1	1	3	1	1	1	9	1	30
9	Easy System Operation	3.00		23	11	17	17	23	17	3	18	6	18	150
	Supports auto-discovery of devices	3.00	0.25	7	1	2	2	7	2	1	7	1	7	36
	Auto-installation	3.00	0.25	2	1	1	1	2	1	1	2	1	2	14
	Error Messages/Codes specified	3.00	0.25	7	7	7	7	7	7	1	2	2	7	53
	Protocol specifies error handling	3.00	0.25	7	2	7	7	7	7	1	7	2	2	48
10, 11	Easy to Maintain/Replace	1.00		6	1	3	3	4	2	1	5	5	1	30
	Software Upgrades can be installed by service technician	1.00	0.25	1	0	2	2	2	1	0	2	2	0	14
	Software Upgrades can be installed by consumer	1.00	0.25	1	0	0	0	0	0	0	2	1	0	6
	Firmware Upgrades can be installed by service technician	1.00	0.25	2	0	0	0	1	1	0	0	1	0	6
	Firmware Upgrades can be installed by consumer	1.00	0.25	2	0	0	0	0	0	0	0	1	0	5
12	Robust messaging capability	1.00		8	5	4	4	3	3	7	6	4	5	50
	Supports 2 way communications	1.00	0.20	2	2	2	2	2	2	2	2	2	2	18
	Supports general data queries	1.00	0.20	2	1	1	1	0	1	2	2	1	1	9
	Supports appliance specific queries	1.00	0.20	2	0	0	0	0	0	2	0	1	0	6
	Message verified with checksums/CRC algorithm/other	1.00	0.20	1	1	1	1	1	0	0	1	1	0	5
	Supports non-static message formats	1.00	0.20	2	2	1	1	1	1	2	2	1	2	12
14	Security Mechanisms	9.00		63	39	13	13	21	21	7	63	21	63	324
	Supports session encryption	9.00	0.33	27	9	9	9	9	9	3	27	9	27	138
	Supports user authorization	9.00	0.33	27	27	3	3	9	9	3	27	9	27	144
	Supports authentication	3.00	0.33	9	3	1	1	3	3	1	9	3	9	42
														0
	Application Layer Totals			261	194	133	161	124	133	176	167	157	155	1661

ASSOCIATION OF HOME
APPLIANCE MANUFACTURERS

AHAM Assessment of Communication Standards for Smart Appliances																										
	802.11				SEP 2.0				Lon										P1901							
Feature / Name	IEEE 802.11n LPEW (SE 2.0 capable)	IEEE 802.11a	IEEE 802.11g	IEEE 802.11b	ZigBee (SEP 2.0 capable)	HomePlug Green PHY (SEP 2.0 capable)	IEEE 802.16 WiMAX	IEEE 802.3	ISO/IEC 14903-3 LonWorks PLCS	ISO/IEC LonWorks 14903-2 TPC	Z-Wave (v4)	3GPP2 / CDMA2000 1x	3GPP / GPRS	3GPP / EDGE	3GPP / UMTS	3GPP / HSPA	3GPP / HSPA+	ISA 100.11a-2009	HomePlug AV	IEEE P1901 / FFT	IEEE P1901 / Wavelet	HomePlug C&C	ITU-T G.hn	ISO/IEC 12139		
Frequency	ISM Band 2.4 GHz - 2.48 GHz U-NII Band 5.8 GHz -	(U-NII Band) f_c=5.1 GHz - 5.8 GHz	(ISM 2.4 GHz Band) f_c=2412 GHz - 2462 GHz	(ISM 2.4 GHz Band) f_c=2412 GHz - 2462 GHz	(ISM 2.4 GHz Band) F_c=2405+5(k-11) k=11..26	1.8 - 30 MHz	700 MHz, 2.5 GHz, 3.6 GHz, many others	[Special-Purpose Cabling]		[Special-Purpose Cabling]	Locale: F_c for 9.6kbps / F_c for 40kbps EU: 868.42 / 868.40MHz US: 908.42 / 908.40MHz HK: 919.82 / 919.80MHz NZ: 921.42 / 921.40MHz AUS:921.42 / 921.40MHz															
Channel Scheme	20 or 40 MHz Blocks	8 non-overlapping 20 - Mhz Channels 52 sub-carriers per Channel	11 overlapping 22 MHz Channels, 5 MHz center separation	11 overlapping 22 MHz Channels, 5 MHz center separation	16 Channels	1155 Subcarriers, 917 For data	Bandwidth dependent : 1.25	[Special-Purpose Cabling]		[Special-Purpose Cabling]	1 channel, 40 kHz wide															
Coexistence	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA	IEEE P1901 ISP	CSMA/CA and TDMA	CSMA/CD	CSMA/CA	CSMA/CD	CSMA/CA	CSMA/CA and TDMA	CSMA/CA and TDMA		CSMA/CA and TDMA	CSMA/CA and TDMA	CSMA/CA and TDMA	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA		
Spreading	OFDM, CCK, DSSS	OFDM	OFDM, CCK, DSSS	CCK, DSSS	DSSS	OFDM	SOFDMA	None		None																
Modulation	Various OFDM Subband	BPSK, QPSK, 16-QAM or 64-QAM	OFDM, CCK, DBPSK/DQPSK+DSSS	CCK, DSSS		QPSK (P1901-FFT: BPSK, QPSK, 8,16,32,256,1024 QAM) Not currently used					FSK + Manchester @ 9.6 kb/s FSK + NRZ @ 40 kb/s															
Diversity	Various Diversity up to 4XMIMO Possible	RX Diversity Possible	RX Diversity Possible	RX Diversity Possible	RX Diversity Possible, rarely used	Not currently used	All types including MIMO																			
Error Correction	FEC	FEC	FEC	FEC	CRC	FEC, Turbo Codes	Turbo Code, LDPC																			
Est. Indoor Range	< 70 m	< 35 m	< 38 m	< 38 m	< 30m (0 dB)	> 66 m wire					> 30 m															
Estimated Link Latency	>= 4 ms	>= 4ms	>= 4 ms	>= 15 ms	>=24 ms	< 100 ms (P1901-FFT: < 2 ms)	> 100 ms	negligable			> 100 m															
Estimated Link Bandwidth	1 Mb/s, DSSS 2 Mb/s, DSSS 4 Mb/s, OFDM ... See standard covering additional modulator settings used in practice beyond LPEW....	6 Mb/s - 54 Mb/s	1 Mb/s - 54 Mb/s	1 Mb/s - 11 Mb/s	250 kb/s	3.8 Mb/s 4.9 Mb/s 9.8 Mb/s					9.6 kb/s 40 kb/s	DOWNLINK(2.45 Mb/s 3.1 Mb/s 4.9xN Mb/s) UPLINK(0.15 Mb/s 1.8 Mb/s 1.8xN Mb/s)														
Scalability Features	Some products can mesh via WDS.	Some products can mesh via WDS.	Some products can mesh via WDS.	Bridges/Repeaters Available	Bridges/Repeaters Available	Bridges/Repeaters Available (P1901-FFT: additionally 32 nodes to a home, 128 homes sharing a transformer (other Pre/post coding																				
Known Scale Limits	Most consumer products default to serving class C subnets, no specific limits. If used, each Pre/post coding, beamforming, etc.	Most consumer products default to serving class C subnets, no specific limits. If used, each WDS Pre/post coding	Most consumer products default to serving class C subnets, no specific limits. If used, each Pre/post coding	Most consumer products default to serving class C subnets, no specific limits. If used, each Pre/post coding	Typical limits are branch factors of 500 nodes to one ESI, designed ED, LQI, CCA	32 nodes to a home, 128 homes sharing a transformer (other Pre/post coding																				
Reliability Features																										
Link Security	IEEE 802.11i, WPS	IEEE 802.11i, WPS	IEEE 802.11i, WPS	IEEE 802.11i, WPS	AES-128-CCM, PKI, PSK	AES-128-CCM, PKI, PSK			Obfuscation only	Obfuscation only	AES-128															
Net Security	IEEE 802.11i	IEEE 802.11i	IEEE 802.11i	IEEE 802.11i	802.11i equivalent mechanisms	802.11i equivalent mechanisms					None															
Generational Compliance	PHY-dependent coverage of 802.11abg	No	Most 802.11g products also offer 802.11b, but are not required to do so.	None	None	Full interop between GP, AV, P1901-fft, forward compatible with future Route-under Repeating					Backward Compatible with v3 Z-Wave															
Link Extension / Repeating	WDS / Repeating Capable	WDS / Repeating Capable	WDS / Repeating Capable	WDS / Repeating Capable	Repeating Supported	Route-under Repeating					yes															
PHY Change / Bridging	Enables 802.2 and WDS widely available	Enables 802.2 and WDS widely available	Enables 802.2 and WDS widely available	Enables 802.2 and WDS widely available	Adapted bridging Supported	Enables 802.2 and lower layer bridging					yes															
Data-flow Direction	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional	Bi-Directional		
Est. Chip Cost	Special variants <\$5	<\$10	Special variants <\$5	Special variants <\$5	<\$5	<\$5	<\$20	<\$5	<\$10	<\$10	< \$15	<\$20	<\$20	<\$20	<\$20	<\$20	<\$5	<\$25	<\$25	<\$25	<\$10	?	?			
Est. Idle Power (W)	negligable	negligeable	negligable	negligable	negligable	negligable		See LPI variants IEEE 802.3az																		
Est. TX Power (W)	LPEW variants < .5 W		Special Variants < 1 W	Special Variants < 1 W	< .3 W	< .5W		See LPI variants IEEE 802.3az																		
Est. RX Power (W)	LPEW variants < .5 W		Special Variants < 1 W	Special Variants < 1 W	< .3 W	< .5W		See LPI variants IEEE 802.3az																		
Est. RX Sensitivity (dBm)											-102 dBm @ 9.6 kb/s -98 dBm @ 40 kb/s															
TX Power Ranges (dBm)				0 to 20 dBm	-17 to 20 dBm						-22 dBm to -2 dBm															