Exposure to Electromagnetic Fields from Wireless Computer Networks (Wi-Fi) in Schools

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Overview

1. Background and motives
2. Objectives and tasks
3. Technical aspects of wireless networks
4. Review of equipment in schools
5. Selection of devices for testing
6. Experimental setup for measurements
7. First measurement results
8. Further work

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Background and Motives
– Rapid Expansion in Wi-Fi use

In 2007, 50% of UK primary schools and 82% of secondary schools made at least some use of wireless network technology

Background and Motives
– Drivers for the Project

Expressions of public concern about Wi-Fi

- Media articles
- Enquiries received by HPA

Lack of quantitative information about exposures

- Comparison with exposure guidelines
- Context with regard to other sources

Existing precautionary advice to discourage non-essential use of mobile phones by children

- Chief Medical Officer
- HPA (NRPB)

HPA Position on Wi-Fi

- The frequencies used are broadly the same as those from other RF applications such as FM radio, TV and mobile phones
- There is no consistent evidence to date that Wi-Fi and WLANs adversely affect the health of the general population
- Results so far show RF exposures are likely to be well within internationally accepted (ICNIRP) guidelines
- Based on current knowledge and experience, exposures from Wi-Fi are lower than those from mobile phones
- There is no reason why Wi-Fi should not continue to be used in schools. However with any new technology it is a sensible precautionary approach, as happened with mobile phones, to keep the situation under ongoing review

http://www.hpa.org.uk/HPA/Topics/Radiation/UnderstandingRadiation/1199451940308/

Project Tasks
Year 1

Market research on popular Wi-Fi devices at schools

- British Educational Communications and Technology Agency (BECTA)
- Suppliers of equipment to schools
- Manufacturers, Wi-Fi Alliance

Setting up of Wi-Fi test facilities at HPA's Chilton site

- Anechoic chamber
- Signal analyser
- Positioning system

Procurement of a selection of example Wi-Fi devices

- Laptops and access points operating in two different frequency bands

Measurements of the EMF strengths around the selected devices during transmission and calculations of radiated powers

- Laptops in 2.4 GHz band

Technical Aspects of Wireless Networks

Configurations

Typical indoor ranges 75-100 m

Up to 300 m of outdoor range

Frequency bands 2.4 GHz and 5 GHz

Number of users allowed is set by the manufacturer.

High end access points support up to 100 wireless connections

Factors affecting human exposure

Distance

Frequency

Output power

Antenna Pattern

Duty factor

Technical Standards for WLAN

IEEE 802.11

IEEE 802.11b

- Widely deployed, basic rate of Wi-Fi,11 Mbps (4.3 Mbps throughput) at 2.4 GHz
- Recommended by some suppliers for teaching resources in large schools

IEEE 802.11a

- Primary standard for WLAN, max 54 Mbps (23 Mbps throughput) at 5 GHz
- Recommended by some suppliers for administration and teacher training

IEEE 802.11g

- 54 Mbps at 2.4 GHz
- Recommended by suppliers for teaching resources in both small and large schools

IEEE 802.11n

- High throughput (74 Mbps), max data rate 248 Mbps at both 2.4 and 5 GHz
- Deployment in schools has recently started

Overall there is no particular trend in the chosen wireless standards in UK schools

Wireless Networks in Schools (Reports from 2007)

Proportion Wireless	Primary Schools	Secondary schools
Whole network	2 %	2 %
Substantial part	21 %	20 %
Small part	26 %	60 %
None of it	50 %	18 %
Number of respondents	*233*	*257*

Network Variant	Primary Schools	Secondary schools
802.11b	36 %	46 %
802.11g	70 %	80 %
802.11a	10 %	16 %
802.11n (pre-)	2 %	2 %
NB. Some schools support multiple standards		

Harnessing Technology schools survey 2007
http://partners.becta.org.uk/index.php?section=rh&catcode=_re_rp_02&rid=14110

Wireless Networks in Schools Survey (2007)
http://emergingtechnologies.becta.org.uk/index.php?section=etr&catcode=ETRE_0001&rid=14124

Standards and Exposure Recommendations

Limiting Emissions

- Europe (ETSI): Harmonised standards EN 300 328 and EN 301 893
- UK (OFCOM): UK Interface Requirements
  (IR 2005 for 2.4 GHz and IR 2006 for 5 GHz bands)

100 mW for 2.4 – 2.5 GHz
200 mW for 5.15 – 5.35 GHz
1 W for 5.47 – 5.725 GHz

Limiting Exposures

- Guidelines from ICNIRP (adopted by HPA)
  - *Basic restrictions* on rate of energy absorption per unit mass of body tissue
  - *Reference levels* in terms of radio frequency power density incident on the body

Results:
Devices in Schools

Image, courtesy of Promethean

Up to 32 laptops can be used in a classroom,

Usually 1-2 access points in each classroom

Interactive whiteboards and hand held interactive slates often have wireless options enabled

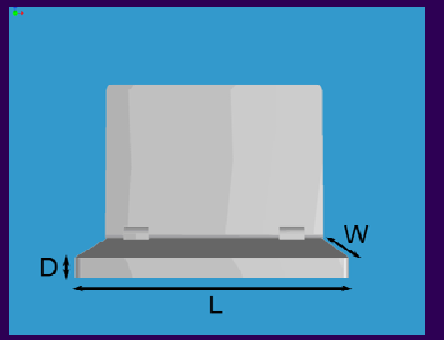
Results:
Devices in Schools

ICT Suites

Laptop Trolleys

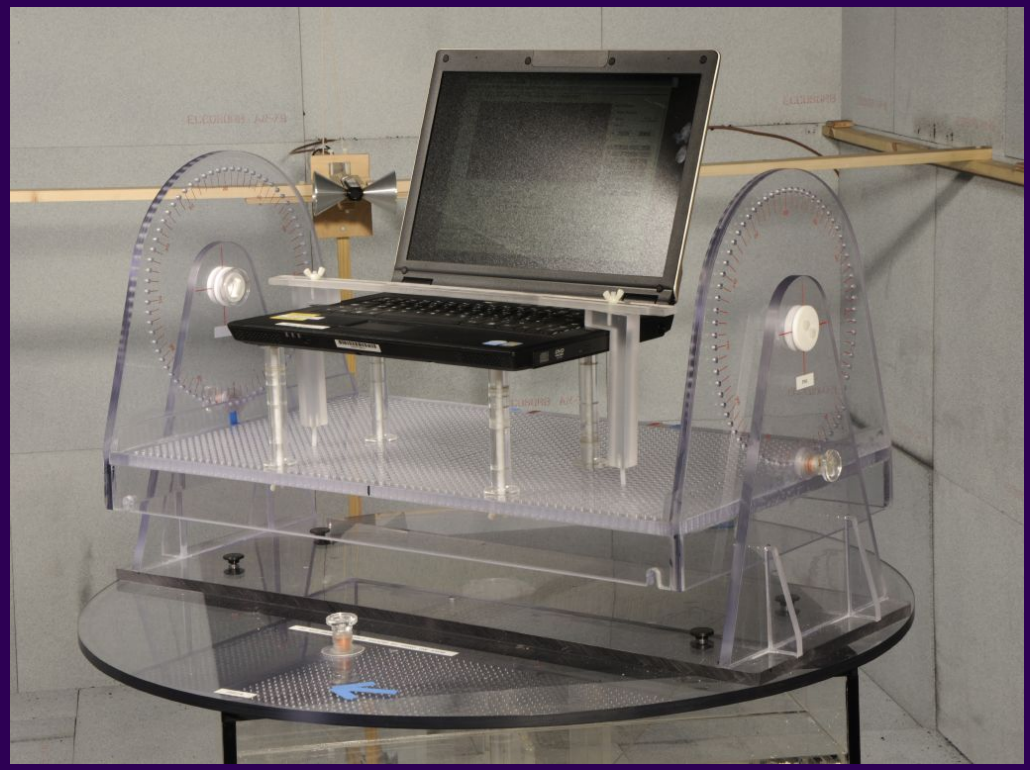
Laptops Selected for Testing
(Examples of Typical Equipment)

Wi-Fi Project ID	Wi-Fi modes	Dimensions LxWxD (cm)	Available frequency channels		Settable power levels
			2.4 GHz	5–6 GHz	
LT01	b/g	34 x 24 x 4	N/S	N/A	N/S
LT02	b/g	36 x 27 x 4	N/S	N/A	N/S
LT03	b/g	36 x 27 x 4	1–13	N/A	25, 50, 75, 100%
LT04	a/b/g/n	37 x 27 x 4	1–11	36–48	1–5
LT05	a/b/g/n	37 x 28 x 4	1–11	36–48	1–5
LT06	b/g	34 x 25 x 4	1–14	N/A	N/S
LT07	a/b/g	32 x 24 x 4	1–11	36–48	1–6
LT08	a/b/g/n	30 x 25 x 4	1–11	36–48	1–5
LT09	a/b/g/n	33 x 23 x 3	1–14	36–64 100–140 149–165	25, 50, 75, 100%
LT10	a/b/g/n	33 x 25 x 4	1–11	36–48	1–5
LT11	a/b/g	26 x 17 x 5	1–14	36–64 100–140 149–165	25, 50, 75, 100%
LT12	b/g	23 x 17 x 4	N/S	N/A	N/S
LT13	b/g	23 x 12 x 3	N/S	N/A	N/S
LT14	a/b/g	40 x 29 x 5	1–11	36–48	1–5
LT15	b/g	28 x 24 x 4	1–13	N/A	1–6



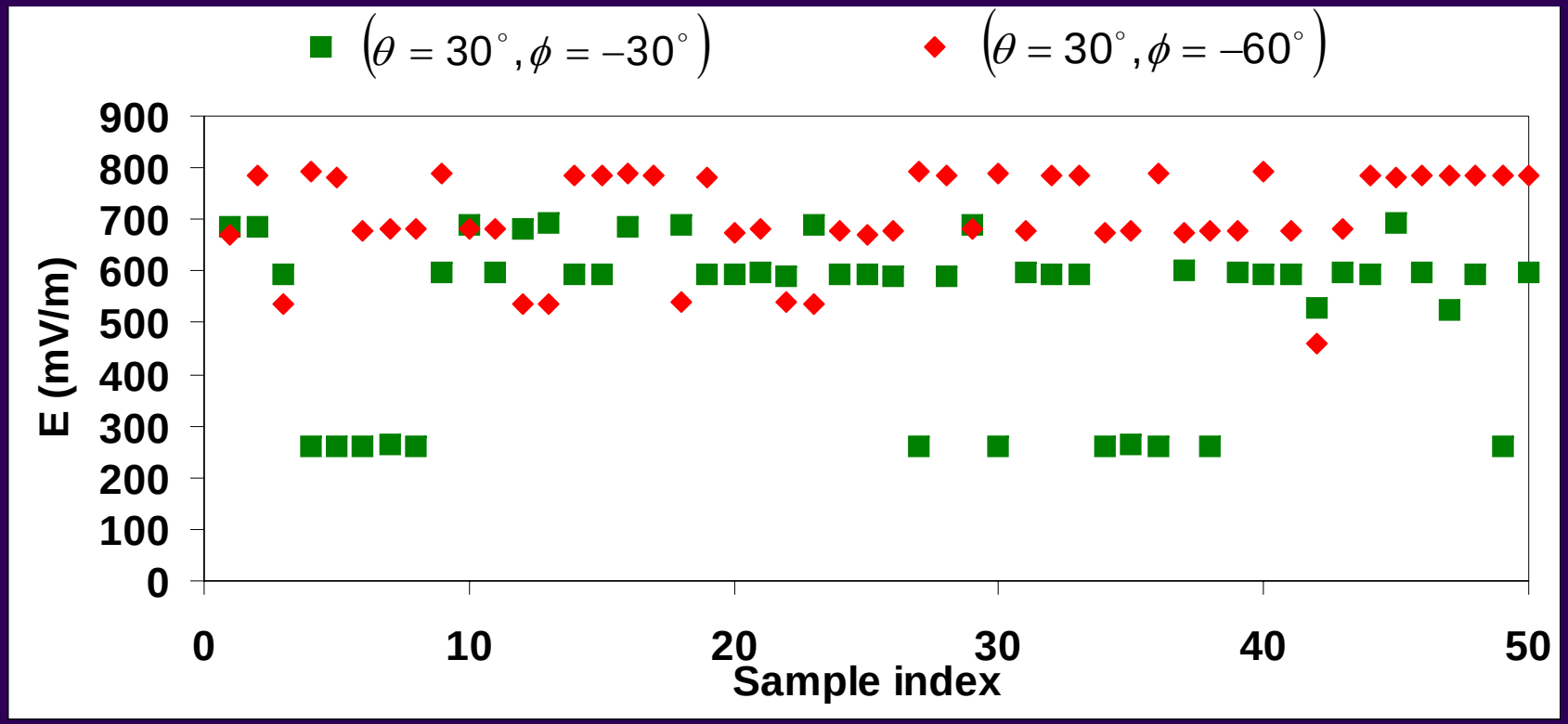
Experimental Facilities Built at HPA Chilton (CRCE)

- Anechoic chamber (3.6 m × 2.4 m × 2.4 m)
- Angular positioner
- Access point
- Receiving antenna
- Signal analyser
- Software acquires electric field strength
    - Angular distribution
    - Function of distance

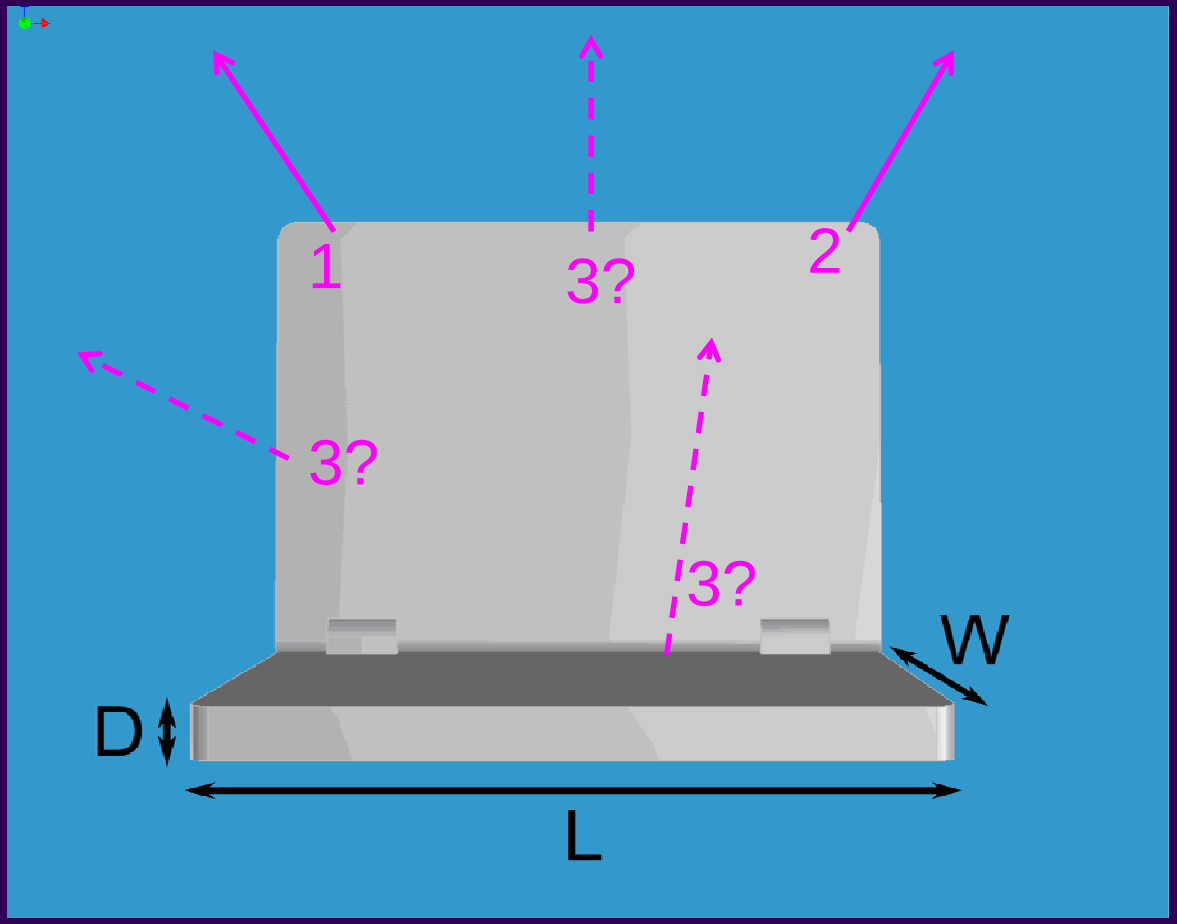


Results:
Multiple Antennas

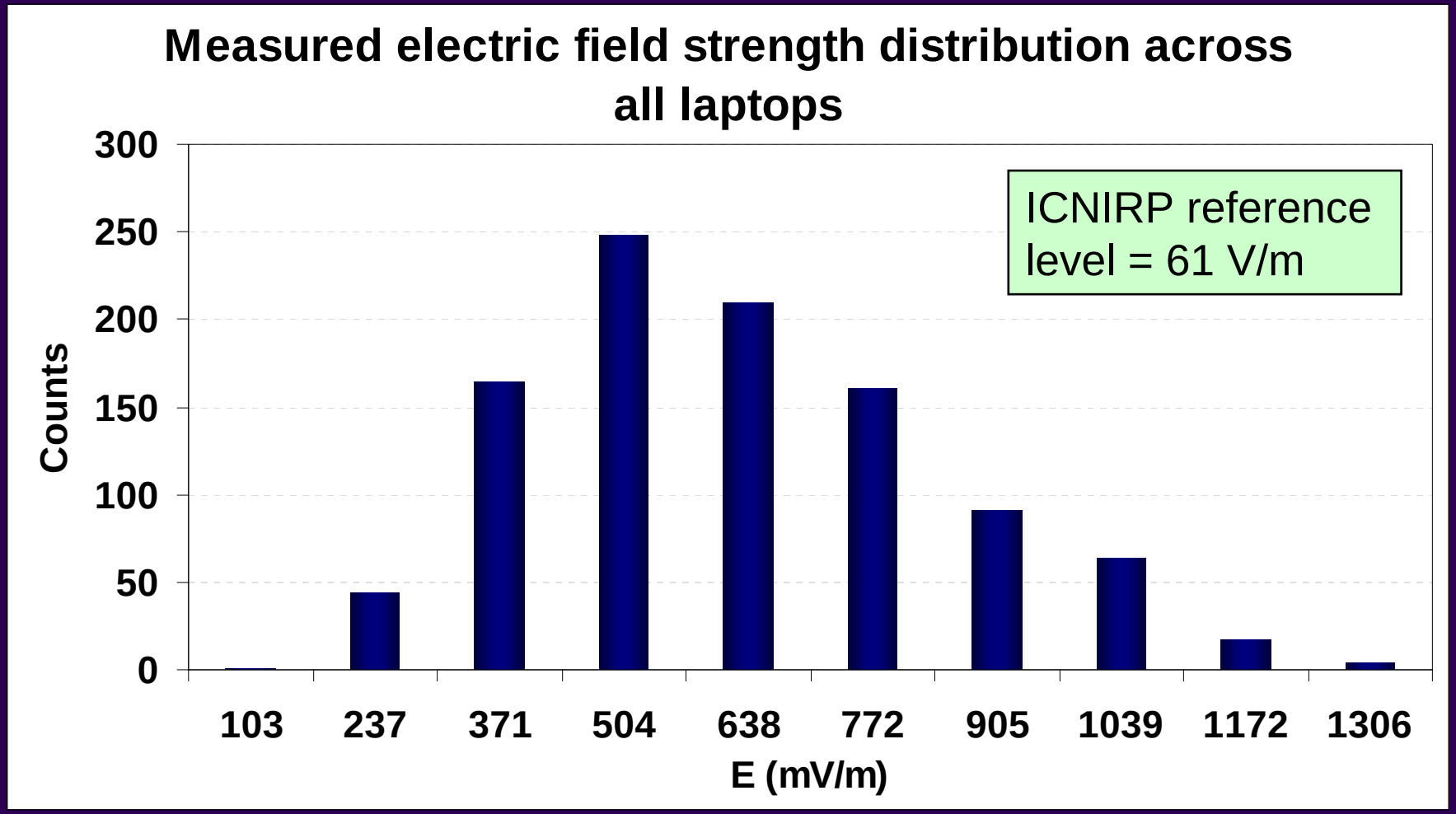
- Field strength measured during 50 captured bursts at each position
- Two (or sometimes three) different levels found



Results:
Typical Antenna locations



Results:
E-field Distribution



Results : Emitted Powers

Laptop ID	θ (°)	ϕ (°)	E (mVm^{-1})	EIRP (mW)	Integrated radiated power (mW)
LT01	60	–30	1045	36	10
LT02	–60	–150	1216	49	19
LT03	–60	–150	1306	57	17
LT04	–60	–150	1048	37	13
LT05	–30	90	719	17	6
LT06	–30	–90	1153	44	12
LT07	–60	180	1055	37	13
LT08	30	120	766	20	9
LT09	–30	120	1009	34	18
LT10	30	150	1054	37	11
LT11	–90	150	1144	32	10
LT12	30	–120	1142	43	17
LT13	90	60	837	22	8
LT14	60	180	970	31	12
LT15	–60	180	909	28	9

Conclusion

- Emitted powers were very low for the 15 laptops
  - Integrated (total) radiated powers ranged from 6 to 19 mW
  - Effective powers (EIRP) ranged from 17 to 57 mW in the direction of maximum emission
    - Within the regulatory maximum of 100 mW
- Results consistent with HPA's present position that exposures are
  - well within exposure guidelines and
  - less than from mobile phones

Project Tasks
Year 2

- Phase 2 measurements of the EMF strengths around the selected devices during transmission and calculations of radiated powers
  - Laptops in 5 GHz band
  - Access points in 2.4 GHz band
  - Access points in 5 GHz band
- Measurements of the proportion of the time that individual Wi-Fi computers transmit during typical school lessons
  - Establish protocol and validate
- Computer modelling of energy absorption in the body when using Wi-Fi equipment under various scenarios
  - Computer model of laptop and exposed person
- Health risk review drawing on the exposure measurements and modelling

Thank You

…… Any questions?

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